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DEPARTMENT OF AGRICULTURE.

U.S FORESTRY DIVISION.

BULLETIN NO. 3.

PRELIMINARY REPORT

ON

THE USE OF METAL TRACK ON RAILWAYS AS A SUBSTITUTE FOR WOODEN TIES.

BY

E. E. RUSSELL TRATMAN, C. E.

TO WHICH IS ADDED

A REPORT OF EXPERIMENTS IN WOOD SEASONING BY THE CHICAGO, BURLINGTON AND QUINCY RAILROAD COMPANY, AND OTHER NOTES.

COMPILED BY

B. E. FERNOW,

CHIEF OF FORESTRY DIVISION.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1889.

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LETTER OF SUBMITTAL.

FORESTRY DIVISION, DEPARTMENT OF AGRICULTURE,
Washington, D. C., February 28, 1889.

SIR: I have the honor herewith to submit for publication as a special Bulletin a preliminary report by Mr. E. E. Russell Tratman, C. E., on the use of metal track for railways, which gives, in concise form, information in regard to the use of this substitute for timber ties in foreign countries.

This report forms a fit sequel to Bulletin No. 1, from this Division, on the "Relation of Railroads to Forestry," which has found so much favor with railroad managers and engineers.

Recognizing that the enormous drafts of the railroads on our timber resources and especially on the young growth—the hope of our future forestry—are among the most dangerous factors in the exhaustion of our timber supply, it is in the interest of forest preservation to keep railroad managers informed of the possibilities in the use of substitutes and the advantages to be derived therefrom.

Through the courtesy of Mr. George C. Smith, manager of the Chicago, Burlington and Quincy Railroad Company, I am enabled to add, as of interest to the same class of readers, an account of the highly valuable experiments on seasoning of timber, undertaken by the chemist of that company.

Notes of interest bearing on the same line of inquiries, such as have accumulated in the Division since the issue of Bulletin No. 1, have also been incorporated in the present issue.

Respectfully submitted.

B. E. FERNOW,
Chief of Forestry Division.

HON. NORMAN J. COLMAN,
Secretary.

METAL TRACK FOR RAILWAYS.

(Preliminary Report on the Use of Metal Track on Railways in Foreign Countries.)

LETTER OF TRANSMITTAL.

BROOKLYN, N. Y., *February* 1, 1889.

SIR: In accordance with the arrangements made some time ago, I have been engaged for several months in collecting material to be used in the preparation of a report to the Department of Agriculture upon the use of metal track upon railways in foreign countries; and I beg to submit, herewith, a brief preliminary report, showing the scope of my investigations, and giving a general idea of the extent to which such track is in use. Attention has for some years past been directed by the Department to the destruction of the forests of this country; and as the consumption of timber for railway ties is very great (as shown in Bulletin 1, of the Forestry Division, on the "Relation of Railways to Forestry," and subsequently in a paper by me presented at the annual meeting of the American Forestry Congress, at Atlanta, Ga., in December, 1888), suggestions have from time to time been made that some form of metal track should be introduced, both to effect an economy in the consumption of our timber resources and to give a more efficient, durable, and economical track. The matter has, however, been given very little practical attention, and it has been generally taken for granted that the use of such metal track in several foreign countries (of which the home and foreign technical journals give occasional information) has been entirely experimental. This is an erroneous impression, the facts being that experiments begun many years ago have led to the adoption of various systems of metal track in different countries. A number of the systems tried have proved fairly efficient in service, if not economical; the systems which have combined efficiency and economy are few, but such a combination has been effected, and there is no reason why it cannot be adapted to and applied in American practice. The experiments are still in progress, and careful records are being kept of the results obtained, both with regard to economy and efficiency; but the questions of the advantages and the feasibility of metal track have passed beyond the experimental stage, and metal track for railways has been brought to a very practical issue.

My first proceeding, after the preparation of the report had been decided upon, was to draw up a list of leading questions respecting the subject of my investigations and to have the list printed. A copy of this list is appended hereto. Personal letters have been written to engineers, managers, manufacturers, etc., in all parts of the world, asking for information, and in each case a copy of these questions has been inclosed in order to show the character of the information desired. At the commencement of this comprehensive system of correspondence I was not very sanguine as to the results, but after about a year's experience I find that they have been eminently satisfactory and have far exceeded my expectations. There have been written about two hundred and fifty separate letters of application, and replies have been received to about one hundred and twenty; some in brief, but a large number in detail, accompanied by plans, etc. These answers required acknowledgment and sometimes a request for further information, and this has entailed a very large amount of personal correspondence; aggregating, in all, between three hundred and fifty and four hundred foreign letters. This work has been rather laborious, but the matter collected has been well worth the trouble, while the work has resulted in the getting together of a mass of information which has probably never before been gathered for purposes of compilation and comparison. The home and foreign technical journals have also been closely studied. The varied information thus obtained, with details of the various systems experimented with or adopted, it is intended to present in full in the main report; meanwhile, I am continuing the investigations.

As the particulars respecting the length of line laid with metal track have been obtained from many separate companies and officers in many countries, it is difficult to even approximate the total mileage; but the figures given in the succeeding pages will prove the great extent of such track in the aggregate.

In Europe it is the usual practice, in addition to the use of metal track for railways, to use steel or iron longitudinals or cross ties, or cast-iron "chairs," for street railway tracks, using no wood at all; but only metal and concrete. Steel ties are also extensively used for contractors' tracks, portable railways, narrow-gauge and light railways, etc., in various parts of the world.

With regard to this country, very little has been done, although from time to time a few ties of different patterns have been put down experimentally. The Pennsylvania Railroad has tried the steel tie used on the London and Northwestern Railway of England, but the trial included the entire system of English track,* with its objectionable double-headed rail supported in chairs; a form of track which it is to be hoped will never be introduced in this country. This trial does not count for much, especially as the tie complete is very expensive, owing to the amount of shop-work. (See "England.")† The Boston and Maine Railroad has tried a few wrought-iron plate ties, and the New York Central and Hudson River Railroad has tried cast-iron "pots" experimentally on a small scale. This latter road will make a careful trial of the "Hartford" steel tie, which promises well; eight hundred of these ties have been ordered and will be laid in April. Another tie about to be given a practical trial is the "Standard" steel tie, in which the rails rest on wood blocks, on end grain, the arrangement being somewhat similar to a form of track tried on the Eastern Railway of France. Of these types of ties, however, I prefer to say nothing further at present, for the reason that however advantageous they may seem, practical service alone can decide as to their practical advantages; and, if successful, they will doubtless be modified to some extent to meet requirements met with in experience, as has been the case with the "Post" and all other successful forms of ties.

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* For description of this, see my paper on "English Railroad Track," in the Transactions of the American Society of Civil Engineers, June, 1888.

† Four or five different types of ties have been tried by the Pennsylvania Railroad Company, all of which have been taken out, with the exception of those obtained from the London and Northwestern Railway (England), which, as stated, have been

It should be borne in mind that metal ties should be adopted not only as a substitute for timber when the latter becomes scarce or expensive, but also (and more particularly on main lines) as giving a better and more efficient form of track for fast and heavy traffic. For a further explanation of this view I would refer to a paper on "Maintenance Expenses of Track on Metal and Wooden Ties," by J. W. Post (with a discussion written by myself), in the Transactions of the American Society of Civil Engineers, June, 1888.* Descriptions of some of the earlier forms of metal track are given in Engineering News, New York, January and February, 1887.

In concluding this introduction, I give the following abstract of the opinions presented at the International Railway Congress, held at Milan, Italy, in 1887: The opinion presented at the Congress at Brussels, in 1885, that metal ties are able in point of efficiency to compete with wooden ties, is not weakened by the results of experience of the two years, and the use of metal ties is extending. In point of economy, considering the first cost and the durability, the result depends upon the material, the state of the metal market, and upon local circumstances. As to the cost of maintenance, the question was not considered to be fully decided on lines with a fast and heavy traffic, but for lines with moderate traffic and speed it was the opinion of the majority that the metal tie presented advantages, especially after the lapse of a sufficient time for the earth works to have thoroughly settled and for the taking up of all slack in the fastenings.

I am, sir, respectfully yours,

E. E. RUSSELL TRATMAN,
Jun. Am. Soc. C. E.

B. E. FERNOW,
Chief of Forestry Division, Department of Agriculture.

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found objectionable. It is also stated that as long as white-oak ties can be got at 65 to 70 cents each it would be foolish to use metal ties, "costing $3 to $4" each. That the cost for metal ties is not necessarily as high as that given as objectionable will appear further on in this report; a good tie (Durand patent) being claimed to be produced from old rails at the cost of $1.—B. E. F.

* See reprint in this Bulletin, p. 25.

CIRCULAR.

The following circular was addressed to various railroad companies and managers in Europe and other countries.

Metal Track for Railroads.

The information outlined below is desired for the purpose of a report to the U. S. Department of Agriculture on the use of metal ties (sleepers) for railroad tracks, and it is requested as a favor that all information furnished should be as complete as possible and sent at the earliest possible convenience.

Respectfully,
E. E. Russell Tratman, C. E.,
144 *Remsen street, Brooklyn, New York, U. S. America.*

INFORMATION.

Railroad:
1. Name.
2. Route.
3. Length of lines laid with metal sleepers.
4. Character of same. (Particulars of grades, curves, etc.)
5. Dates when laid.
6. Engineer in charge.
7. Character of traffic.
8. Weight of locomotives and weight on driving wheels.

Sleeper:
9. Longitudinal, transverse, or bowl.
10. General form.
11. Dimensions, including thickness. (Figured drawings.)
12. Weight.
13. Material.
14. Spacing center to center.
15. How treated. (Paint, anti-rust process, etc.)
16. Manufacturer.
17. First cost, at factory or delivered.
18. Expense of maintenance.
19. Attachment of rails. (Details and drawings.)
20. Arrangements for curves.

Sleeper—Continued.
21. Tie-rods; if used, how attached and adjusted for gauge.
22. Durability.

Track:
23. Material of ballast.
24. Behavior of ballast under sleeper.
25. Construction of road-bed. (Drawing.)
26. Section and weight of rail.
27. Rail joints; how made.
28. Rail joints; on sleeper or suspended.

29. Reasons for adopting metal sleepers.
30. General results: satisfactory or otherwise.
31. Is there trouble with maintenance of track?
32. Is there trouble with rail attachments?
33. Is there trouble from breakages; how and where do they usually occur?
34. Efficiency, etc., as compared with wooden sleepers.
35. Cost, material, and durability of wooden sleepers.
36. Climate; and effect of same on metal or wooden sleepers.
37. General remarks.
38. Opinions.

REPORT.

EUROPE.

England.—In England, steel ties have during the past few years been tried to a greater or less extent on quite a number of the principal lines. Foremost among them is the London and Northwestern Railway, which has between 20 and 30 miles of track laid with the steel cross-tie invented by Mr. F. W. Webb, the locomotive superintendent of the road. In 1888 there were 83,204 of them in use, and the experience with them had covered then six and one-half years. These ties have been experimented with on the Pennsylvania Railroad.

The general type used is the steel "inverted trough" in different forms, either rolled or stamped. As the system of track, however, includes the double-headed rail, these ties are fitted with the usual heavy cast-iron chairs to hold the rail (the Webb tie has the chairs made of steel plates), and the track is unnecessarily heavy and costly. The chief difficulty is said to be in adapting the steel tie to the double-headed rail, it being difficult to make a good piece of work. The North-eastern Railway, however, is trying steel ties under flange rails weighing 90 pounds per yard, which is a step toward the ideal track for main lines.

France.—Experiments with metal cross-ties have been made on nearly all the principal railways, and a large number of types have been tried, but several of them have been of complicated design, and therefore uneconomical. Longitudinal systems have been tried to a small extent.

On the State Railways a number of trials have been made, and with some forms of tie very good results have been obtained, enabling a reduction to be made in the maintenance staff. In 1886 there were ordered 17,000 ties of the "Post" type and 80,000 ties of the old "Berg-et-Marche" type. In 1888 there were (*a*) 2.10 miles laid with the "Paulet-Lavallette" ties, with double-headed rails in chairs; (*b*) 7.35 miles laid with a tie similar to the "Post" type, with double-headed rails, and 30,000 more of these ties had been ordered; (*c*) 8.86 miles laid with similar ties, but with flange rails. Of these (*a*) had been laid in 1885, (*b*) and (*c*) in 1887. On the Paris and Bordeaux line, 4.4 miles of "Vautherin" ties of uniform thickness were laid between November, 1886, and February, 1887; 4.5 miles of "Vautherin" ties of varying thickness (similar to the "Post" type) were laid in February and March, 1887, and .56 mile was laid with the "Boyenval and Ponsard" ties in April, 1888.

The Paris, Lyons and Mediterranean Railway used an old type of iron tie several years ago, but abandoned it on account of the ties costing more than the wooden ties and giving a less firm and durable track;

this latter defect was probably due to the old-fashioned "gib and cotter" fastening employed. These ties were laid in 1862 and following years, and had all been taken out in 1872. Good results have been obtained with metal ties on the Algerian system controlled by this company. (See "Africa.")

The Northern Railway laid trial sections of its Belgian lines with the "Severac" and "Bernard" ties in 1885, and laid 10,000 of the former on its French lines in 1888.

The Western Railway, which used the old double-headed rail, has experimented with iron ties upon which the rail chairs were cast; about 1.3 miles were laid in 1887.

The Eastern Railway has tried steel ties with wooden cushions or bearing blocks under the rails, and has also laid about one hundred of the "Post" ties.

Holland.—In this country probably the most extensive and most valuable, because continuous and systematic, trials have been made, and the trials have resulted in improvements which have served to develop the now well-known and extensively-used "Post" steel cross-tie of varying thickness, the thickness being increased under the rail seat. The "Post" tie, the invention of Mr. Post, the engineer of permanent way of the Netherlands State Railway Company, is economical both in construction (owing to its requiring a minimum of shop-work, all of which adds to the cost of a tie) and in maintenance, and has proved very efficient in service.

On the Netherlands State Railways the experiments have been in progress since 1865, and the steel tie designed by Mr. Post and improved by him from time to time in the light of practical experience has been adopted on this system. In the early part of 1888 the system, which comprises 910 miles of road, had 91 miles of track laid with these ties. Of 10,000 ties laid in 1865, 9,550 were still in the track and were expected to last twenty years more, although they were of the earlier type of the tie, which has since been improved upon. As to breakages, out of 162,634 ties laid, not one had broken.

In the early part of 1888 there were in use 457,300 ties (about 23,800 tons) of the "Post" type in Holland, Belgium, France, Germany, Switzerland, and Asia (colonies); about 272,700 ties (about 12,700 tons) more, including ties for narrow-gauge railways and for the rack railway in Sumatra, were being manufactured; making a total of about 730,000 ties, or 36,500 tons, of this one type. (See page 25.)

Belgium.—On the Belgian State Railway system the "Post" tie has been laid, but it is heavier than that used on the Netherlands State Railway and heavier than the inventor considers necessary or desirable. It should be noted that it is not economical to use more metal than experience has shown to be necessary. Experiments have been made on rather a large scale, and in 1887 three types were experimented with on various lines, and one of these types appeared to meet the requirements for fast and heavy traffic. In 1885 it was decided to put down

35,000 ties of the "Post" (old) type, 35,000 ties of a type invented by the chief engineer of the road, and 5,000 ties of the "Bernard" type. Some "Bernard" ties were also laid in 1886–'87.

The Grand Central Railway has also had satisfactory results with metal ties. In 1873 the superintendent of permanent way reported that he was fully satisfied with the experience then acquired with metal ties, but he was unable to adopt them further at that time owing to a great advance in the price of iron. In his reports for 1886 and 1887 he stated that the favorable results had been still more marked, and during 1887 there were 6,000 metal ties laid.

Metal ties of the "Coblyn" type, for light railways, have been definitely adopted by the Société Anonyme des Chemins de Fer Économiques, and have also been tried on the lines of the Société Nationale des Chemins de Fer Vicinaux, the Netherlands lines, the Liegeois and Luxembourg division (on Belgian territory) of the Netherlands State Railway, and on the Liege and Seraing line. Metal ties have been tried on the Belgian division of the Northern Railway of France, including 5,500 ties of the "Bernard" type.

Germany.—On the State Railways a number of different systems of metal track of longitudinal and transverse types have been tried for several years, and some types have been regularly adopted on certain divisions. The investigations and trials are still in progress. In 1887 the State Railway system had a length of about 13,193 miles, with about 23,662 miles of track; of this amount about 5,530 miles had metal track—3,131 miles being laid with cross-ties and 2,399 miles with longitudinals. Very careful records of the trials have been kept. In the year 1886–'87 there were laid 868,262 new cross-ties and 64,094 longitudinals. In February, 1888, 500,000 "Post" ties were being made for German lines.

For the Rhenish Railway system 308,000 ties (10,775 tons) were purchased in 1877–'79. On the Left-Bank-of-the-Rhine Railway, which comprises 1,681 miles, there are 943 miles with metal cross-ties and 211 miles with longitudinals, the balance being on wooden cross ties. The first cross-ties were laid in 1876 and the first longitudinals in 1872. Since 1879 metal sleepers only have been used. On the Elberfeld division of the Prussian State Railways (1,646 miles) there are 790.5 miles laid with wooden ties, 762.5 with iron ties, and 93 miles with iron longitudinals. They were laid in different years between 1869 and 1880. The experience with iron longitudinals and cross-ties was very favorable, but still better results have been obtained since steel was introduced. Wooden ties are still used in great numbers, partly on account of their lower first cost and partly on account of the policy of the Prussian Government to keep up the supply of timber by domestic cultivation and forest management.

Austria.—In this country, longitudinal systems of metal track have been extensively used. The Northwestern Railway has a total of 59½ miles of track laid with the "Hohenegger" system of longitudinals, and the economy over wood is reported to be noticeable. These longitudinals have been laid in small sections year by year since 1876; the earlier ones were of iron, but the latter ones are of steel. The "Heindl" system of longitudinals is in use on a number of roads; the first were laid in 1883, and at the end of 1887 there was an aggregate of about 141 miles laid with this system of track, a considerable portion being on mountain divisions and including 6.634 miles on the Arlberg tunnel line.

Switzerland.—The Central Railway had 100,000 metal ties in use at the end of 1884, and proposed to lay 30,000 per annum till its whole system had been thus laid. The Western and Simplon Railways began using metal ties in 1883, and have been very well satisfied with them. The Gotthard Railway uses them very extensively, and they have also been adopted on the Mount Pilatus Rack-Railway. In February, 1888, the Hoerde Works reported that they were delivering 160,000 "Post" ties to the Gotthard Railway and 160,000 to the Western Railway.

Italy.—Metal track has been used very little, if at all, and oak ties are obtainable in ample quantities and at a moderate price; and as there are extensive timber resources such track will not be necessary for many years. It has been proposed, however, to lay steel ties on some sections of the Mediterranean Railway system. The Government has used steel ties for short military railways in its African campaigns.

Spain.—The line from Bilbao to Las Arenas has 7.1 miles laid with steel cross-ties, and it is believed that they will prove more economical than wood. The line is 1-metre gauge. The Almanza, Valencia and Tarragona line has 251 miles laid with the De Bergue system of cast-iron plates connected by tie-rods. This system is found to give greater economy, and the gauge is maintained better than with wooden sleepers. The division between Valencia and Tarragona was laid with this track in 1860, and the division between Almanza and Valencia in 1873.

Sweden.—On the State Railways about two-thirds of a mile were laid with metal ties, for experimental purposes, in June, 1886. This is the only case where they have been used in Sweden or Norway.

Denmark.—On the State Railways steel cross-ties were laid for about 18 miles in 1883–'84; but the results, as reported to me in 1888, have not been entirely satisfactory, owing to the insufficient weight and strength of the ties.

*Russia.**—Metal ties have only been used to a very limited extent, on two branch lines, and even there they have not been sufficiently used to enable any reliable conclusions to be drawn from the experiments.

AFRICA.

Cape Colony.—The Cape Government Railways have some sections of the lines laid with cast-iron bowls; they are arranged in pairs and connected by transverse tie-rods. The Delagoa Bay Railway, one of the new lines opening up the interior, is laid principally with steel ties.

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* The metal ties laid on the Moscow Kursk Railway were removed because their maintenance was found more expensive than that of wooden ties. It is claimed that at present prices for wood and for metal in Russia, the metal ties, weighing 105.8 pounds, with an estimated duration of thirty-five years, were two and a half times as expensive as the pine ties impregnated with chloride of zinc, lasting ten years, and one and one-half as expensive as oak impregnated and lasting six years. Conditions in Russia, however, are exceptional as regards labor and material.—B. E. F.

Senegal.—About 5,000 ties of the "Severac" type have been ordered for the railways in this French colony. Cast-iron bowls are used on the French island of Réunion.

Egypt.—On the Egyptian Agricultural Railways, wrought-iron plates connected by tie rods have been used, and also cast-iron "pots" or bowls. In the English campaign of 1885 a short length of light railway of 18-inch gauge, with corrugated steel cross-ties, was laid at Suakim, but the line was soon taken up.

Algeria.—Metal ties are used on the Algerian lines controlled by the Paris, Lyons and Mediterranean Railway Company (France); 10,000 ties were laid in 1870, and have given good results. In 1867–'69 the Algiers and Oran line put down 90,000 iron ties of the "Vautherin" type; the Bône and Guelma line put down 3,500 ties of the "Severac" type and 2,500 of the "Boyenval-Ponsard" type. It is estimated that the use of metal ties has saved one-fourth of the labor formerly required for maintenance, or about $60 per mile per annum.

ASIA.

India.—In this country, steel cross-ties and cast-iron bowls and plates (the latter types arranged in pairs) are very extensively used, and the use of metal track is extending very rapidly, large contracts being frequently awarded for the companies' and the Government lines. Even in Burmah, where wood has been generally used till recently, steel ties are beginning to be introduced.

About 525,000 tons of steel ties have been sent out from England during the last few years, and there are nearly 300 miles of the State lines now laid with this form of track; a large number of miles of private companies' lines are also laid with steel ties. The general results are reported to be good, and the ties give, on the whole, much satisfaction. They are used for lines of 1 metre and 5 feet 6 inches gauge.

There are over 1,600 miles laid with cast-iron track of different types, and these also give satisfactory results in general. Such tracks have been in use for twelve or fourteen years. Of the "Denham-Olpherts" type alone more than 2,000,000 pairs have been made for double-headed rails and about 600,000 pairs for flange rails. On the East Indian Railway there were 1,311,000 of these "Denham-Olpherts" plate sleepers at the end of 1887, and the breakages since 1885 had averaged only 0.84 per cent. per annum. They give good results in reducing the work of maintenance, there being a saving of about 6½ per cent. of renewals per annum. In some of these sleepers wooden cushions are used for the rails to rest on. On one division of the Indian Midland Railway the percentage of renewals of the "Denham-Olpherts" plate sleepers was 0.31.

Japan.—A few cast-iron "pot" sleepers were laid when the first lines were built, about 1871, but they have nearly all been taken up again and hardly any now remain in the track, while for new lines timber ties are used exclusively.

China.—Steel cross-ties are to be tried as an experiment on the new railway which was opened last year.

AUSTRALIA.

Queensland.—The first metal sleepers ever made in Australia have been tried in this colony, an experimental section of a few miles long having been laid with the "Phillips" type. This is a steel cross-tie intended for prairie work, where the track is laid on the surface of the ground; it is designed to be used without ballast, being simply packed with surface soil. Some years ago about 1,000 wrought-iron ties were laid, but they only lasted about five years, as they generally fractured under the rail-seats, owing, it is said, to defective fastenings; they were laid in broken-stone ballast.

In regard to the "Phillips" type, Mr. Phillips kindly reports to me as follows, under date of January 2, 1889, and it is especially interesting as showing that metal track is adapted for other lines than those with heavy traffic:

> I have just returned from North Queensland, where I have been constructing a section of railway 36 miles in length on my system. The country I am dealing with is between the port of Normanton, in 17° 45′ S. lat. and 141° 10′ E. long., and a new goldfield by the name of Croydon, situated about 85 miles E. S. E. from Normanton. The country is almost uniformly even, and the Norman River is the only important river crossed. The first 4 miles are over gravel ridges, when a descent of 1 in 70 for half a mile brings the line down to the level of the river flats; the soil is dark clay with a slight admixture of alluvial sand. This description of country extends to 14 miles, where the river is crossed with a low level timber bridge (principally 20-feet spans) on a sandstone rock bottom. Thence to Croydon the country is very uniform in character—fine sandy soil, covered with a more or less thick forest of inferior and stunted timber, sometimes dense enough to be called brush or scrub. There is no forest timber of sufficient dimensions in the district available for ties or bridge work, neither is there any stone for ballast, except by quarrying below the surface, and that is sandstone of an inferior and very soft description. The country is almost uniformly even, except at the 4-mile peg, where there is a cutting of about 5 feet and an embankment of equal height. I commenced track-laying July 7, and completed 32 miles on December 29; fully seven weeks were lost through non-delivery of ties, so that the average rate of progress was 1¾ miles per week of six working days. The number of men employed in (*a*) clearing track 66 feet wide, (*b*) grubbing, (*c*) ploughing, harrowing, and rolling central width of 10 feet, (*d*) track-laying, (*e*) lifting and packing ties, and (*f*) straightening track, never exceeded 65, with one team of bullocks (12) and one horse. Cost per mile for labor only, $630; wages for laborers, $2.50 per day; gangers, $3.15. The ploughing, harrowing, and rolling cost $75 per mile, and is included in the $630. The total cost was under $15 per lineal foot. The best day's work was .525 mile, and the best week's work a little over 2 miles. No ballast has been provided and no side or cross drains cut; the only waterways are at well-defined and water-worn channels. The total timber bridging on the 36 miles is 1,108 lineal feet, and only one box-drain has been put in. From 20¼ miles to 36 miles there is not a single water-way of any description. The cost is under $15 per lineal foot.
>
> The material train has never failed to run to the head of the road daily, from the commencement of track-laying, although there have been some very heavy thunderstorms with 1 to 2 inches of rain-fall in an hour. The track is laid with steel flange rails, 41¼ pounds per yard, 26 feet long, fastened to mild steel cross-ties, weighing 84 pounds each, 11 ties to a rail length. The average gross load of the material train,

100 tons. The locomotive employed is a six-wheeled engine of English build. The country passed through is believed to be the softest in wet weather to be found in Australia, but so far no trouble has been experienced with the line. The country is infested with white ants (termites), and ties of the best hard woods of the colony will not last more than 3 years in the form of ties. The government now in power are not very favorable to my system, but I hope to be able to induce them to complete the Croydon Railway on my system. I believe my system might be applied with advantage to your prairie country subject to heavy rain-falls.

New South Wales.—About 1,000 steel cross-ties were laid in 1882. In 1887 it was reported that they were in bad condition, but this may have been due (if correct) to the fact that the manufacture of steel ties was in its infancy in 1882.

South Australia.—In March, 1888, the agent-general in England reported to me that metal sleepers were being laid on a new line 145 miles long, not then open to traffic.

SOUTH AMERICA.

Argentine Republic.—In this State, cast-iron "pot" sleepers are used almost exclusively, except in the far west and north. The Buenos Ayres Great Southern Railway, which began operations in 1865, has 13¾ miles of double track and 819½ miles of single track laid with cast-iron sleepers of an improved design. They are adopted on account of the difficulty of procuring good hard-wood ties in sufficient quantity and the greater expense of these wooden ties; also because they give a more rigid and satisfactory track. The Central Argentine Railway has 246 miles laid with cast-iron track. The Santa Fé and Cordoba Railway ordered 20,000 steel ties in England in 1888.

Chili.—Steel ties have been tried to a small extent, but the type was considered too heavy and expensive. Previous to the award in November last, to an American syndicate, of the contract for building about 780 miles of railways for the State, proposals had been invited by the Chilian legation in France for the supply of 739,400 metal ties 9 feet long and 725,100 ties 4¼ feet long.

United States of Colombia.—There has been some talk of adopting metal ties on the Bolivar Railway.

MEXICO.

The Mexican Railway (Vera Cruz line) is using a large number of steel ties of the type in general use in India, and has obtained very good results with them, especially at times when the road has been flooded. These ties were first used in 1884, and at the end of June, 1888, there were 46¼ miles of track laid with steel ties. The Mexican Central Railway has been contemplating the adoption of the same type of tie on the mountain division of the road, the advantages being that they last longer than wooden ties and keep the track in perfect gauge.

The above report is respectfully submitted for consideration.

E. E. RUSSELL TRATMAN,
Jun. Am. Soc. C. E.

FEBRUARY 1, 1889.

Appendix A.

THE "POST" TIE.

This tie, of which so much has been heard, is probably the most successful of all the various types of metal ties that have been put in service, and the success is largely due to the care which has been taken in noting the results obtained and in making such improvements as experience has shown to be desirable. Consequently, the present form of the tie is the result of many improvements, and represents several years of experience and careful study. It is a cross-tie rolled from mild steel (Bessemer, Thomas, or Siemens-Martin); its section is that of an inverted trough, with flaring sides forming a section of a polygon; it is narrow and deep in the middle, the ends are closed, and the bottom edges are thickened to form a rib. One of its special features is its varying thickness, giving an ample thickness of metal at the rail seat, where the greatest strength is required, and a less thickness at the middle and ends. Thus the weight of the ties as now used is from 110 pounds to 121 pounds each, corresponding to 126.5 and 139.15 pounds if they were of uniform section. This feature represents, therefore, an economy of 15 per cent. of metal as compared with a tie with a uniform thickness equal to the maximum thickness of the "Post" tie. In the operation of rolling, the varying thickness is given and also the shape of the tie, while the bending of the ends to give the rails an inward inclination of 1 in 20 (in accordance with European practice) is done during the same operation.

The shape of the middle portion of the tie is designed with a purpose, as it is claimed that by narrowing this portion the ballast is kept from working away from under the rail seat, and in this way a stable road-bed and track are secured, thus diminishing the work of maintenance. It prevents the tendency of the ballast to work towards the middle and form a ridge on which the tie would rest, giving a rocking motion to the track, but gives it a tendency to pack well under the rail seat. The increased depth of this portion gives additional strength to resist bending and also offers increased resistance to creeping.

The following are the principal dimensions, given in the original metric measure and also reduced to feet and inches: Length over all, 2.55 to 2.65 metres (8.364 to 8.692 feet); width over all at rail seat, 235 millimetres (9.40 inches); width over all at middle, about 5.30 inches; width of rail seat, 110 millimetres (4.40 inches); width of end, 280 millimetres (11.20 inches); depth under rail, 74.5 to 75.5 millimetres (2.98 to 3.02 inches); depth at middle, 125 millimetres (5 inches). Thickness of cross-section at rail seat varies as follows: Thickness at bottom of flange, 6 millimetres (.24 inch); thickness at upper part of flange, 7 millimetres (.28 inch); thickness at rail seat, 9 to 10 millimetres (.36 to .40 inch); thickness at bolt-holes, 12 to 13 millimetres (.48 to .52 inch); thickness at middle and ends, 6 to 7 millimetres (.24 to .28 inch). The rib on the lower edge of the flanges has a depth of about 18 millimetres (.72 inch), and projects about 13 millimetres (.52 inch) beyond the outer face of the flange.

For narrow-gauge and light railways the dimensions would be reduced in accordance with the weight, and for such lines a weight of 72.6 to 77 pounds is considered sufficient.

For rail fastenings reliance has been placed upon bolts, and the results have been entirely satisfactory; the fastenings keep tight, prevent vibration and rattling, and require little attention after the track has become well settled. The bolt-holes are oblong, and have rounded corners. The bolt used is 91 millimetres (3.64 inches) long and 22 millimeters (.88 inch) in diameter; it has a T-head 38 by 46 millimetres (1.52 by 1.84 inches), and a cam-shaped or eccentric neck 22 by 30 millimetres (.88 by 1.20 inches), for the purpose of allowing an adjustment of gauge at curves, switches, etc. The bolt passes up through the tie and through a "crab" washer which bears on the flange of the rail and the face of the tie; a Verona nut-lock is then put on and the nut screwed down upon it. The upper face of the washer and the lower face of the nut are indented, so as to give a good hold on the nut lock. The ties are sent out to the track with the fastenings separate in kegs, or with the bolts in place and the nuts loosely screwed on, according to the wishes of the division engineers; some of whom prefer one plan and some the other.

This tie presents the following advantages:

First. Economy in material; owing to the maximum thickness being given at the rail seat and a less thickness at the middle and ends, this effects a decided saving in weight and first cost.

Second. Economy in manufacture; owing to the shaping, bending, and varying of the section being all done in the operation of rolling, thus reducing the shop-work to a minimum; which is an important consideration.

Third. Economy in maintenance; owing to the little care and attention required, as shown by years of actual service.

Fourth. Efficiency in making a good track; as also proved by years of actual service.

Fifth. Adjustment; owing to the arrangement of the fastenings permitting the gauge to be widened at curves and narrowed at switches; which is an important feature when a tie is adopted on a considerable length of track.

E. E. R. T.

Appendix B.

SOME AMERICAN METAL TIES.

The International tie.—This is a rolled steel tie, the section of which resembles a printer's "brace" (⏞); originally it was made in two pieces, riveted together at the middle flange, but it is now to be rolled in one piece. The dimensions are as follows: Length, 8 feet; width, 10 inches; side flanges, 2¾ inches deep; middle flange, 2 inches high; thickness, from 3/16-inch at the lower part of the side flanges to 5/16 inch at the middle. The middle flange is cut away in two places for the rails. The fastenings consist of flat wrought-iron clips, one on each side of the rail, which are bolted to the flange of the tie and have projections which bear upon the rail flange. Some of these ties have been in use for more than two years on the Boston and Maine Railroad and the Maine Central Railroad; the Long Island Railroad is now giving them a trial.

The Hartford tie.—This is a rolled steel tie, of inverted trough section, with a channel or groove along the whole length of the top table, and having the ends curved down to hold the ballast. The dimensions are as follows: Length, 7 feet 6 inches; width at top, 8 inches; width at bottom, 10¼ inches; depth, 2½ inches; thickness, ⅜ inch at sides and 5/16 inch at top; the channel or groove is 2½ inches wide and ⅝ inch deep. The weight is about 120 pounds. The fastening for each rail consists of two clamps ⅝-inch thick, with a hooked projection at the broad end, which holds the flange of the rail; these clamps are wedge-shaped in plan, and lie in the channel above mentioned. A bent bolt, with its head at an angle of 53 degrees with the body, is used on each side of the rail; the head is on the under side of the tie and the body passes up through the tie and clamp, the nut bearing on the inclined face of the clamp. This is the fastening as improved by Mr. Katté, the chief engineer of the New York Central and Hudson River Railroad. By this arrangement, the bolt being at an angle, a strong grip is secured, and there is little tendency to jar the bolts loose; to prevent such loosening, however, the bolt has the Harvey grip thread, which forms a nut-lock in itself. The fastening permits of a very wide range of adjustment of gauge. These ties have not yet been tried, but the New York Central and Hudson River Railroad will lay 800 of them in April, and careful observations will be made as to the results.

The Standard tie.—This is a steel tie of channel section (⊔) stamped to shape from a plate. The bottom is cut away at the middle, and is bent up at an angle to offer resistance to lateral motion, the ends being open. The rail does not rest upon the vertical sides of the tie, which are cut away for a depth of three-fourths of an inch under the rail, but rests upon a block of preserved wood (placed with the grain vertical). The tie is intended to be filled with ballast. The fastenings consist of **Z**-shaped clips, the upper part holding the rail-flange and the lower part taking a bearing on the under side of the bottom of the tie; the upright web is nearly vertical, but curved so as to grip the wood block. A bolt passes horizontally through the two clips and the block, near the top of the latter, holding all the parts firmly together. At the rail-joints it is intended to use a tie of extra width, with wide clips and two bolts, and it is claimed that this fastening will be sufficient in itself, and will obviate the necessity of using splice plates. These ties have not yet been in service, but arrangements have been made for their manufacture, and it is said that they will soon be tried on a Western road. The claim is made that they are specially adapted for roads with a narrow width of ballast, owing to the resistance to lateral movement being at the middle instead of the ends of the tie.

The Taylor tie.—This is an iron or steel tie on the "bowl" system, each tie consisting of a separate piece under each rail, connected by a third piece forming a tie-bar. The rail-bearers are short pieces of inverted trough section, placed longitudinally with the rail, and have a vertical transverse slot through which the deep flat tie-bar passes. The inside flange of the rail is held by clips, forming a part of the top table of the trough, and the outside flange is held by a hooked projection at the end of the tie-bar. No bolts or other loose parts are used.

The Toucey tie.—This is a cast-iron "pot" tie designed by Mr. Toucey, general superintendent of the New York Central and Hudson River Railroad. Each tie consists of two "pots," of **H**-section, with outward flaring sides; the "pots" are connected by a tie-rod, the ends of which are bent at right angles to fit into a hole in the horizontal web, the rod passing through a hole in the side. The "pots" are 18 inches long, $9\frac{3}{4}$ inches wide on top, $16\frac{1}{2}$ inches wide at bottom, and $8\frac{5}{16}$ inches deep; the thickness varies from one-half inch to 1 inch. The space above the web is filled with an oak block, to which the rail is secured by the Bush interlocking bolts. These ties are in use at the Grand Central Depot in New York City.

A channel tie.—A channel tie was used by the Pennsylvania Railroad for some years subsequent to 1880. In that year some were laid on the Filbert Street extension, and in 1885 about 400 or 500 were laid on the main track in the West Philadelphia yard. The tie consisted of an ordinary 7-inch channel iron (⊓) 8 feet 6 inches long; the ends were closed by a piece of angle-iron riveted on, and a cross piece of angle-iron was also riveted inside the channel, just under the outer flange of the rail. The fastenings for each rail consisted of a piece of angle-bar riveted to the face of the tie (the rivets passing through the angle-bar, tie, and inside angle-iron) on the outside of the rail, and a loose flat clip on the inside of the rail, fastened by bolts. Writing in 1886, Mr. Brown, the chief engineer of the Pennsylvania Railroad, said:

> These ties cost from $3 to $4 each. As long as we can get good oak ties for not exceeding $1 each, I would not recommend making the change, although they give perfect satisfaction and are no more trouble to keep in line and surface than wooden ties.

THE DURAND TIE.

This tie, among the latest patented in this country, has been in use on a private trial line in the French Alps.

It resembles most nearly the "Post" tie.

It is produced by converting old rails into metal sheets, from which the tie is stamped out by special machinery, requiring no further shop-work than the fastening of the bolts, which are welded to the tie while hot.

The cross section is of the "Vautherin" or "Zores" type, like the "Post" tie, narrowed, and depressed in the center and slightly curving towards the ends, as well as to the middle of the tie. Lengthwise corrugations on the face of the tie under the rail-seat, and if deemed necessary, vertical corrugations on the side-faces, are intended to give additional strength, allowing a saving of metal as against the "Post" tie. The width on top under the rail-foot is 10 inches and across the lower edges 12 inches.

The ends are open but can be closed if desired by a special cap, which is put on after the tie is placed and can be easily removed if necessary, permitting access to the lower side, bolts, etc., without removing the tie entirely. Experience, however, with the open-end type seems to have proved that the curvature of the ends is sufficient to prevent the blowing out of ballast.

The fastening of the rails is effected by means of four bolts with specially-fitted T-heads, which are inserted and partially welded to the tie from below during its manufacture, and are prevented from turning by a shoulder in the tie. A washer of soft metal is so adapted as to prevent any loosening of nuts above, an indentation on the lower side fitting into a similar indentation in the tie, and one flange being bent upwards after screwing down.

For curves, switches, etc., the adaptation of shape, inclination, and gauge is effected in the manufacture by interchangeable pieces in the stamping apparatus.

The placing of the tie is effected by laying it on the ballast and burying it in the same by means of a rocking motion with the help of levers inserted into holes made at the ends of the tie in manufacturing. No digging of a tie-bed, no tamping is needed. The drainage, a very important requirement, is well provided for.

The weight of the tie is made variable by either rolling the metal-sheets to three-sixteenths of an inch, which gives a 65 pound tie, or five-sixteenths of an inch, which will make it about 100 pounds.

The cost is claimed to be $1 or $1.35 respectively, if manufactured in the United States. The cost of manufacture is calculated at 30 cents, allowing a railroad company to use up the old rails. The plant for rolling the rails to shape and stamping the tie is simple; its cost is estimated at $5,000.

The Durand tie, with less metal, promises to give the same strength and is more easily placed than the "Post" tie.—B. E. F.

METAL TIE NOTES.

The following matter has been appended as of interest in the discussion of the desirable change from wooden to metal ties.

These notes originate in part with Mr. Tratman, or else are copied from other publications.

The ephemeral literature on the subject is growing rapidly, and by the time Mr. Tratman's final report will go to press, it will have become desirable, with it, to present in abstract the useful information which has thus accumulated. By that time it is hoped that more experiences from trial tests on railroad lines of our own country may also be recorded.

As this Bulletin goes to press, two interesting items of news on the railroad tie question have reached this office. The one relates to the remarkable durability of lignum-vitæ cross-ties on the Panama Railroad—thirty-five years. That there is any likelihood, as some papers seem to anticipate, that this discovery will in any way influence the use of metal ties by possible competition of this wooden tie, I am inclined, for various reasons, to doubt.

Perhaps of more influence on this subject may become the introduction of stone sleepers in combination with the "Elastic Tie-Plate," which was originally intended to improve the track on wooden ties, but has proved itself of service on rock sleepers in an experiment made by the Ystad-Eslof Railway in Sweden. Yet we are inclined to think that even this kind of substructure, if found as efficient as is claimed, would not threaten as much competition with the metal track as it might at first appear to do, except under special conditions.

The theoretical requisites for a perfect metal tie are now quite well understood and have been discussed at length in Bulletin I, from this Division. The task of inventors henceforth must be, while complying with these theoretical requisites, to do it in such a manner as to reduce the cost of the manufacture to its lowest possible figure without loss of required strength. With the extendeg experience before us there can not longer be a doubt that it is possible to construct a metal tie which will be superior in all respects to wooden ties; yet to bring its first cost down to such a figure that the future saving in its maintenance need not enter into consideration, but may be taken as an agreeable surprise in the cost of management—this is what railroad companies are most bent on obtaining. Especially in our country, where the present accounting outweighs in importance all future possible profits, this consideration alone, of reduced first cost, may be sufficient to work a revolution in the use of railroad ties. On the other hand, the bugbear of cheapness, which is often mistaken for an equivalent of economy, is apt to mislead the inventor into risking the factors of safety and strength in order to attain cheapness.

"If a man wants a 'cheap' track he had better continue to pay 50 and 75 cents for wooden ties. And if he wants an economical track he must use steel ties with enough metal in them to insure permanency."

There is also no doubt that the metal tie which is suitable for one set of conditions is not suitable for others. The amount of traffic, and especially the condition of track and ballast, will dictate changes in shape, weight, etc.

It had been the intention to review all the patents which had concerned themselves with introducing metal for railway tracks, but the large number—not less than 256 patents so far, very many of which are obviously impracticable—made the task too laborious for the practical result to be expected from it. Therefore, only a brief reference list to these patents has been prepared by Mr. Tratman.

The first suggestion for the use of metal track seems to date back to the year 1839; a patent by J. Stimpson, proposing a construction of metal and wood combined, similar to a construction now much used in street railways. The next attempts did not follow until 1857, 1858, and 1861.

The flood of patents begins with the year 1883, the last five years having produced not less than one hundred and sixty devices.

Some of the more prominent devices, which have been actually manufactured in the United States, are briefly described in Appendix B.

B. E. FERNOW.

MAINTENANCE–EXPENSES OF TRACK ON WOODEN AND METAL TIES.

By J. W. Post, permanent way engineer, Netherlands State Railroad Company.

Read at the annual convention of the American Society of Civil Engineers, July 2, 1888.

Though the track of European railroads shows in material, construction, and maintenance a great difference from the track on American lines, the following data concerning the use of steel cross-ties, gathered methodically since 1865 on the lines worked in Holland, Belgium, and Germany by the Netherlands State Railroad Company, may be of some interest to American railroad engineers.

The first trial of metal ties on the Netherlands State Railroad dates from 1865, in which year 10,000 Cosijns ties* were laid. In 1880 these ties, of a system now considered poor, had given satisfactory results as to the metal part during their fifteen years of service, but the oak blocks had to be frequently renewed. Moreover, the following considerations induced the company to search for a good metal tie:

First. It was feared that prices of timber would gradually rise, owing to the increasing devastation of forests.

Second. Even with the wood deemed best for ties, viz. oak, it was difficult to secure satisfactory results; some lots of oak ties, severely inspected, appeared first-rate when new, but had to be renewed after only one year of service. The time of felling seems to be of great importance, and cannot be determined at the moment of purchase even by the severest inspection.

Third. Even the best methods of impregnating proved unreliable; of ties coming from the same boiler some were quite saturated, others only on the surface; some lasted one year only, others twenty years. Uniformity in this respect is desirable for the track.

Fourth. No timber merchant guarantees his ties; whereas steel ties are generally guaranteed for two years.

Fifth. There is a great loss of interest during the time timber ties are piled in order to dry; whereas metal ties are often in the track before being paid for.

Sixth. There is a great loss of timber ties by bursting, caused by sunshine, water, frost, driving the spikes, etc.

Seventh. Timber ties being heavier than metal ties, the transport to the place where they are put in the track is more expensive.

Eighth. The difficulty and cost of the respiking and readzing of timber ties, and of the replacing by new ones, increases with the daily number of trains. Ties of more durable material are desirable also from that point of view.

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* This tie consisted of an I beam laid horizontally, thus ⊢⊣, with a wooden block under each rail.

Ninth. The selling price of old metal ties is considerably higher than the price of old timber ties.

Tenth. A calculation* of the total annual sum required for purchase, laying, maintaining, and renewing tracks on timber and on metal ties gave a favorable result for the metal.†

All these considerations induced the company to charge the writer in 1880 to study, both at home and abroad, the different systems of metal ties then in use, both from the point of view of manufacture and of maintenance, and to propose a method of trial enabling the company to get the most complete information possible on the subject.

This charge resulted in the following different systems of ties and fastenings being laid in the track from 1880 to 1888:

	Pounds.
Type I, Vautherin section; iron	88
Type II, Vautherin section; iron	103.84
Type III, Haarmann section; mild steel	110
Type IV, Haarmann section; mild steel	114.4
Type V, Haarmann-Lichthammer section; mild steel	95.48

	Ties.
In 1881, type I	4,133
In 1882, type II	4,001
In 1883, type III	2,089
In 1883, type IV	2,090
In 1884, type V	11,680

And from 1885 to 1888, about 126,000 ties, types VI, VII, VIII and IX, making about 150,000 ties of ten different types (including Cosijns). Of each ot the types, trial lengths, under different circumstances of grades and curves, were put under special observation, every hour of maintenance work and every renewed piece being scrupulously noted. As a base of comparison 1,120 first-rate new oak ties were laid in the track, the rails being fastened with the ordinary spikes The plate shows the different types of ties used.

At the same time different systems of fastenings were tried on the metal ties.

By trying the best improvements in shape, material, and manufacture, and by eliminating every year the faults of the preceding types, Mr. Post gradually arrived at types of ties and fastenings which, having shown great advantage in every respect over the preceding types, have now been adopted as standards for this railroad.‡ (Types VIII and IX.)

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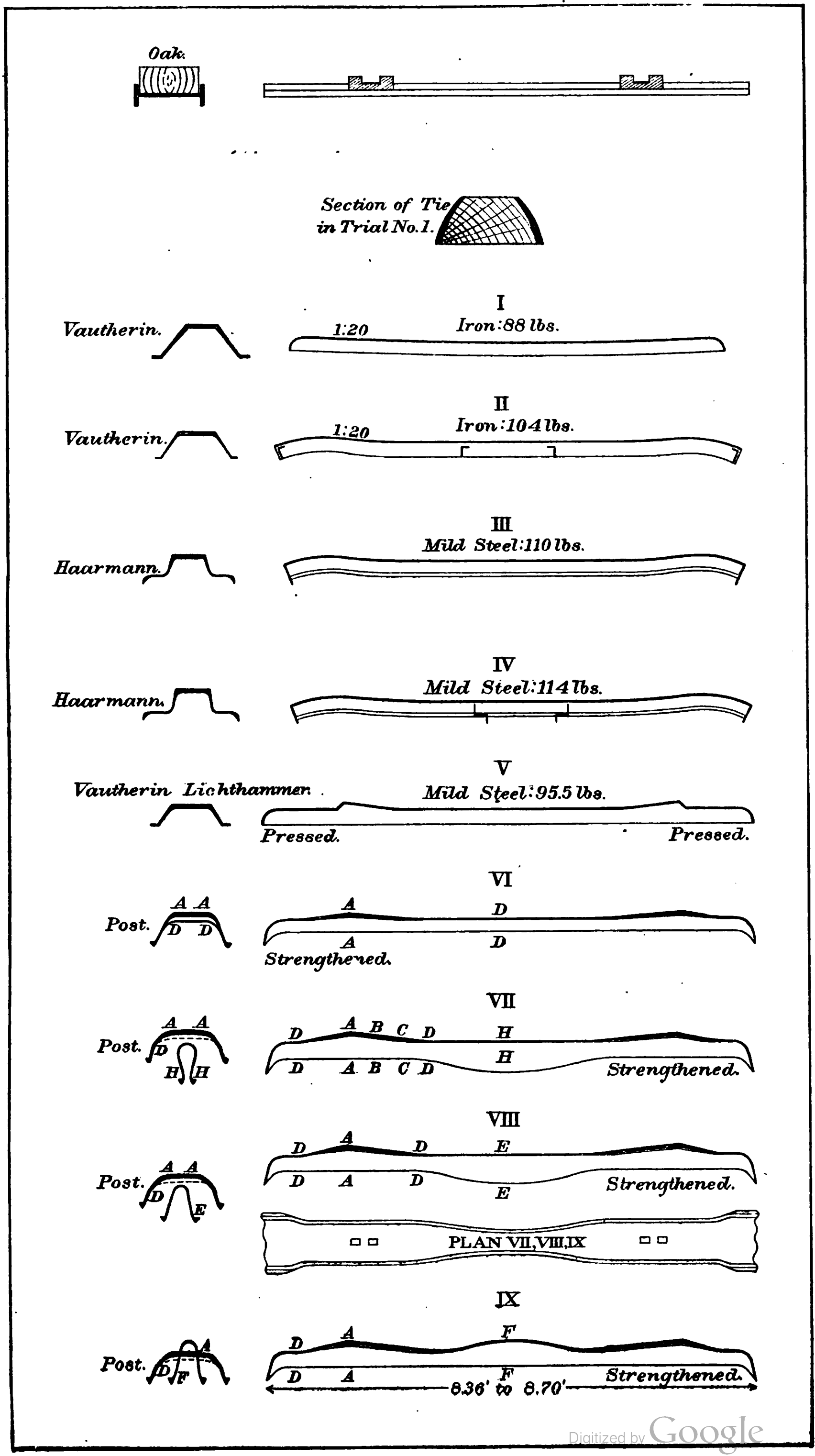
* For methods of calculation see Bulletin I of Forestry Division; also the valuable report of the American Society of Civil Engineers, June, 1885, on the "Preservation of Forests."

† Many important improvements introduced since have increased the advantage of metal over timber.

‡ Other railroads have, to their great satisfaction, followed this example. A total of about 457,300 ties (about 23,800 tons) of the Post types VI, VII, VIII, and IX is now in service on different lines of Holland, Belgium, France, Germany, Switzerland,



DEVELOPMENT AND TYPES OF THE "POST" TIES.

Types VI, VII, VIII, and IX are in mild steel rolled to a variable section, strengthening at rail seats and tilt 1 in 20 being obtained directly by rolling, thus preserving the steel from damage at the vulnerable spot (rail seats) by bending or pressing. These ties weigh 50 to 55 kilograms each, corresponding to 57 to 63 kilograms per tie of uniform section BB (economy 15 per cent.). Type VI, without the narrow waist, like all preceding types, had not quite the same stability as the later types with narrow waist; indeed, this reduction of breadth in the middle causes the principal reaction of the ballast to work at the rail seats, eliminating the balancing action of the track which takes place when the support is in the middle, particularly on badly ballasted roads or with neglected packing. Moreover, the increased height at the center gives greater rigidity to the tie. The wedge waisted tie VII is, unfortunately, of difficult manufacture, and so types VIII and IX are practically esteemed the best, and all agree that they give remarkable results.

The ends are closed and project downward 2 inches into the ballast. The tests prescribed for inspection are very severe. The author executed a series of tests to ascertain whether annealing the ties after punching the holes does pay or not; his conclusion was, that with mild steel annealing is not necessary, but is desirable if it can be done at small expense.

The ties are tarred if they have to remain a long time beside the track. The price, including two years of guaranty, varies from $22 to $26 per ton.

The fastenings show the following improvements, gradually introduced and tried by Mr. Post. The surface of nuts and clips is roughened to facilitate the grip of the Verona nut-lock. The clips, if rolled (mild steel annealed), get three fillets for the same reason; if stamped (iron or mild steel), they are indented like the nuts. In both cases the clip has a large contact with the surface of the tie in order to reduce the wear. For the same reason the head of the bolt (iron or soft manganese steel) is large. The bolt must not be less than ⅞ inch diameter. The collar of the bolt, which is eccentric, to enable widening of gauge on curves by turning the bolt 180 degrees, fits tight into the tie hole; this hole being rounded in the corners to avoid cracks, the bolt collar is rounded accordingly. The Verona nut-locks are of the very best quality, severely tested as to elasticity and sharpness of points, and are guaran-

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and Asia (colonies). About 272,700 more (about 12,700 tons), comprising the narrow-gauge and rack-road ties for Sumatra, are ordered and being manufactured now, making a total of about 730,000 ties (or 36,500 tons). See on this subject:

(*a*) Mr. Bricka's official report to the French minister of public works.

(*b*) Mr. Kowalski's official report to the Milan Railroad Congress, 1887.

(*c*) Report of Vincennes Exhibition, 1887, highest award to Netherlands State Railroad Company and to the writer.

(*d*) Annual Report, 1887, of the French Society for the Advancement of Industry; silver medal awarded to the writer.

teed. The price of these improved fastenings does not exceed 24 cents per tie.

The statistical results as to cost of maintenance gathered to January 1, 1888, on twenty-four trial lengths, are shown in the accompanying table. Columns 1 to 14 give the particulars of sections, condition of laying, types, etc., and columns 15 to 22 the expense of maintenance per day and per kilometre in francs.

The statistical data gathered to January 1, 1887, and the close and scrupulous observations of the trial divisions, allowed the company to report seventeen conclusions to the Milan Railroad Congress in 1887.

The service from January 1, 1887, to January 1, 1888, having fully confirmed the opinions of the company on these seventeen points, the following conclusions are still applicable to the statistical data gathered to January 1, 1888, as contained in the accompanying table:

(1) Trials 11 and 14 are on curves of 350 metres radius and 16 millimetres per metre grade. Oak ties occupying this place previously had to be respiked every year, causing great cost of maintenance; the rail flange cut the spikes 3 to 4 millimetres, thus giving every year a gauge widening of 6 to 8 millimetres. Several ties of type III, on the contrary, taken from the track for inspection after 1,553 days of service, showed only a widening of 2 millimetres, the exterior bolts (of the old type "A") being worn only 1 millimetre by the rail flange. The tie surface only showed a slight amount of corrosion, and the holes were not in any way enlarged or ovalized. Considering the unfavorable conditions under which these ties were, these are very good results; in no year did the expense amount to 2 francs per day kilometre, and the average day kilometre is only 1.39 and 1.40 francs (columns 18 to 22).

(2) Trials 3 and 9 being on marshy ground, the result may also be considered as favorable; in no year as much as 2 francs per day kilometre, and average day kilometre 0.95 franc and 0.88 franc (columns 15 to 22).

(3) As to consolidation (about 2,300 days), the only trials comparable to the base trial No. 1 (oak ties) are trials 2, 3, 4, and 5. Though two of these four trials are under unfavorable conditions, there is no sensible difference between the average day kilometre of trials 2, 3, 4, and 5, and the day kilometre (0.605 franc) of trial 1, a very favorable result indeed, considering the following facts:

(*a*) Type I is now considered a poor system, each of types II to IX being great improvements. Had one of the more perfect types been used on these trials, still better results would have been obtained.

(*b*) Respiking and re-adzing of the oak ties of trial 1 had begun in 1886, and has to be continued in 1888 and following years, increasing the cost of maintenance with the age of the wood.

(*c*) With the trials on metal ties, on the contrary, there is a tendency shown of a decrease of expense as the permanent way becomes set.

(*d*) On trial 1 only ten oak ties had to be replaced by new ones since 1881; this renewing, however, will go on increasing with the age of the wood, thus increasing, apart from the cost of purchase, the daily expense (work) of trial 1. The renewal of ties on the other twenty-three trials, on the contrary, was *nil* since 1881 (not one metal tie being broken), and will be *nil* for man y years.

(4) The day kilometre of trials 6, 7, 8, 12, and 17 does not exceed 0.88 franc; those of trials 10, 13, 15, 16, 18, and 19 are below 0.60 franc, though these eleven trials date only from 1883 and 1884.

(5) The time of observation for types VI, VIII, and IX (trials 20 to 24), has been too short to form any definite idea of the mean day kilometre; meanwhile everything tends to show that these types will give even better results than types I to V.

(6) The average expense for laying and maintaining the twenty-three trial-lengths 2 to 24, has not been greater than would have been occasioned by the timber ties laid on the same places. The supplementary expenditure for these trials, apart from the trouble of statistics, etc., is therefore *nil*.

The close observation of the permament way and of the manufacture of ties and fastenings led the company to the following conclusions:

(7) A part of the road near Liége, twenty-five trains daily; curve of 530 millimetres radius, 16 millimetres per metre gradient, after having been carefully packed, was left for forty months without any other work than occasional nut-tightening. This shows that a good road, with steel ties, once properly packed, requires no more scrupulous attention and maintenance than one laid with timber ties; on the contrary, it would have been dangerous to have left a track situated as this was, and laid with timber ties, for a period of three and a half years.

(8) The diagrams of the self-registering gauge-measure show that the gauge is much more regularly kept on metal ties than on timber (even new oak) ties.

(9) The position of the rail, which often changes on timber ties, is not variable with the metal ties.

(10) The lateral displacement of the track is insignificant with metal ties, even on curves of short radius, providing that the tie is closed at the end.

(11) The breadth of the ballast bed may be made a little smaller with the narrow-waisted metal ties (types VII, VIII, and IX) than with ordinary metal or timber ties.

(12) The respiking and re-adzing of trial No. 1 necessitated to 1888 the replacing of two bearing plates and 1,081 spikes by new ones. The renewal of fastenings on the metal ties is insignificant, especially with the adopted type "C."

(13) Iron is not recommended for metal ties; mild steel is superior to it in every respect, viz. manufacture, inspection, rigidity, and durability.

(14) Alternating joints have given satisfactory results, especially in curves of short radius.

(15) Suspended rail joints have given the best results on metal ties, providing the angle splice-bars be strong and the distance between joint-ties small.

(16) Types VII, VIII, and IX fulfill all conditions for properly imbedding the tie in the ballast. If the packing is done properly, and does not exceed 1½ feet from each side of the rail, the track can never become balancing, through the ballast working towards the middle of the tie and leaving the ends unsupported, for the shape of the tie drives the ballast towards the rail seats, both transversely and longitudinally. Generally the ballast soon forms into a compact cake, adhering to the interior of the tie, thereby augmenting both the base and the mass of the track.

(17) The track men, who generally abhor novelties, have soon learned, owing to practical instructions, to appreciate the steel ties and to make an excellent track with them.

The company closed these seventeen conclusions by quoting at the Milan Congress the following statement from the annual report of Mr. Charles Renson, resident engineer of the Liegeois section, which will be received with great appreciation on account of the distinguished and impartial manner in which this engineer has organized the trials of metal ties on that section:

> A single track with ties, Type VIII or IX (latest form), having twenty-five trains per day with curves, gradients, ballast, etc., as the Liege-Hasselt section, can be, after four years of consolidation, maintained in proper order at the rate of one hundred working days per year—kilometre. A gang of four men, working two hundred and fifty days a year, of which fifty days are given to other work, are able to maintain in good condition 8 kilometres of permanent way.

The Netherlands State Railroad Company, having experienced the great advantage of practical experiments made on trial sections of track, has continued experiments as follows, in order to gather information on other points:

Between Tilburg and Breda, four parts of equal length were laid in 1886 on the same track, to compare the cost of maintenance and of renewal between: (1) Ordinary steel rails (33 kilograms per meter) on timber ties. (2) Heavy steel rails (40 kilograms per meter) on timber ties with two Post's steel, toothed bearing-plates on every tie. (3) Heavy steel rails (40 kilograms) on heavy Post steel ties. (4) Ordinary steel rails (33.7 kilograms per meter) on ordinary Post steel ties.

The time of observation is yet too short for any conclusion.

Between Tilburg and Breda, four parts of equal length are being laid now in the same track to compare the cost of maintenance and of renewal between: (1) Ordinary steel rails on ten timber ties per 9 meters of track. (2) Ordinary steel rails on eleven timber ties per 9 meters of track. (3) Ordinary steel rails on twelve timber ties per 9 meters of track. (4) Ordinary steel rails on twelve timber ties per 9 meters of track, with alternating joints.

Between Weurno and Helmond the same four comparative trial lengths are being laid on ten, eleven, and twelve Post steel ties per 9 meters of track.

The information gathered by these methodical researches will be of great value, not only for the Netherlands State Railroad but for railroading generally; the best remedy for scanty net earnings being a reduction of the expenses of maintenance and renewal.

Cost of maintenance on trial tracks with wooden and metal ties, Netherlands State Railroad Company.

Trial number.	Trains per day.	Section of line.	From—	To—	Gradient in milimeters per meter.	Radius of curves in meters.	Length of trial in meters.	Number of ties.	Types.	
									Ties.	Fastenings.
	1	2	3 *Kilom.*	4 *Kilom.*	5	6	7	8	9	10
1	25	Liége-Tongres	15.620	14.612	12.0	500	1.008	1.120	Oak.	Spikes.
2	25	do	16.666	15.620	12.0	750 straight.	1.046	1,133	I.	A.
*3	25	Bilsen-Hassett	41.093	40.170	1.2	straight.	0.923	1,000	I.	A.
6	25	Liége-Tongres	7.946	7.432	16.0	1,000	0.514	600	II.	B.
7	29	Liors-Flamalle	1.831	1.393	level.	1,000	0.438	500	II.	B.
8	25	Tongres-Bilsen	25.031	24.570	8.0	straight.	0.461	500	II.	B.
*9	25	Bilsen-Hassett	43.625	43.349	4.0	straight.	0.276	300	II.	B.
11	25	Liége-Tongres	3.790	3.640	16.0	350	0.150	201	II.	B.
12	25	do	12.707	12.528	13.0	500	0.259	300	II.	B.
14	25	do	4.002 3.640	3.790 2.836	16.0	350	1.016	1,328	III, IV.	A.
17	25	do	12.528	12.315	13.0	500	0.215	250	IV.	A.
21	25	do	4.412 4.765	4.302 4.748	16.0	530	0.117	200	VI.	C.
22	25	do	8.000	9.000	16.0	1,000	1.000	1,081	VI.	C.
4	14	Hassett-Wychmael	22.238	21.130	2.9	straight.	1.108	1,200	I.	A.
*5	14	Wychmael-Achel	32.673	31.940	3.4	straight.	0.733	800	I.	A.
10	14	Hassett-Wychmael	8.408	7.301	3.9	straight.	1.107	1,200	II.	B.
1	14	do	1.562	1.218	6.5	500	0.344	400	II.	B.
1	14	do	1.218	0.765	6.5	500	0.453	500	III, IV.	A.
16	14	Achel-Eindhaven	47.334	47.795	0.8	2,000	0.461	500	III.	A.
18	14	do	47.795	48.256	level.	straight.	0.461	500	IV.	A.
19	14	do	46.868	47.334	0.8	straight.	0.466	505	V.	A.
20	14	do	52.709	52.032	1.0	2,000 straight.	0.677	735	VI.	C.
23	14	do	57.342.50	56.425.9	1.0	2,000	0.083.40	93	VIII.	C.
21	14	do	57.425.95	57.509.10	1.0	2,000	0.083.15	95	IX.	C.

* Marshy ground.

Cost of maintenance on trial tracks with wooden and metal ties, etc.—Continued.

Trial number.	When laid.	Date when observation commenced.	Days in service.		Cost of maintenance in francs per kilometer per day.							
			From beginning of observation to January 1, 1888.	1887.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	Average from beginning of observation to January, 1888.
	11	12	13	14	15	16	17	18	19	20	21	22
1	1881	July 1, 1881	2,375	365	0.139	0.217	1.226	0.296	0.493	1.101	0.423	0.605
2	1881	....do	2,375	365	1.120	0.423	0.576	0.195	1.086	0.538	0.842	0.650
*3	1881	Sept. 1, 1881	2,313	365	1.900	0.589	1.884	0.256	0.941	0.383	1.125	0.952
6	1882	Jan. 1, 1883	1,826	365	......	......	1.214	0.489	0.638	1.112	0.552	0.801
7	1882	....do	1,826	365	......	......	1.562	0.277	1.169	0.494	0.573	0.817
8	1882	....do	1,826	365	......	......	1.676	0.333	1.255	0.118	0.046	0.725
*9	1882	....do	1,826	365	......	......	1.687	0.861	0.953	0.278	0.625	0.881
11	1883	Oct. 1, 1883	1,553	365	......	......	0	1.084	1.974	1.187	1.666	1.389
12	1885	.. do	1,553	365	......	......	0	0.891	0.465	0.264	0.746	0.587
14	1885	.. do	1,553	365	......	......	0	1.647	1.792	0.867	1.619	1.392
17	1883	....do	1,553	365	......	......	0	1.132	1.111	0.498	1.006	0.879
21	1885	Apr. 1, 1885	1,005	365	......	......	......	......	0.036	0.078	0.983	0.495
22	1887	June 1, 1887	214	214	......	......	......	......	......	......	0	0
4	1881	June 15, 1881	2,390	365	0.0977	0.595	0.614	0.158	0.156	0.418	0.297	0.407
*5	1881	Sept. 1, 1881	2,313	365	1.584	1.027	0.720	0.526	0.556	0.509	0.227	0.652
10	1882	Jan. 1, 1883	1,826	365	......	......	1.077	0.475	0.329	0.503	0.597	0.596
13	1883	Sept. 15, 1883	1,569	365	......	......	0	0.433	0.418	0.879	0.583	0.513
15	1883	.. do	1,569	365	......	......	0	0.246	0.412	0.258	0.419	0.313
16	1883	Mar. 1, 1884	1,401	365	......	......	......	0.311	0.143	0.329	0.802	0.421
18	1884	....do	1,401	365	......	......	......	0.290	0.372	0.553	0.651	0.471
19	1884	....do	1,401	365	......	......	......	0.551	0.897	0.277	0.492	0.554
20	1885–'86	June 1, 1886	579	365	......	......	......	......	......	0.144	0.252	.212
23	1887	Sept. 1, 1887	122	122	......	......	......	......	......	......	0	0
24	1887	.. do	122	122	......	......	......	......	......	......	0	0

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REMARKS.—These trial-lengths are on single-track road. First group, 25 to 29 trains per day; second group, 14 trains per day. Rails, 38 kilograms per meter; steel angle splice bars. Ballast—gravel, sand, and cinder. Heaviest engine on these lines 50 tons, with 13 tons on the heaviest axle; heaviest engine on other lines, 63 tons, with 15.9 tons on the heaviest axle. Speed up to 50 miles per hour (on some parts 60 miles per hour). A day's maintenance per man costs 2.19 francs; the results of columns 15 to 22 may be transformed into days by dividing by 2.19. The figures in columns 15 to 22 give the expense for work of maintenance, not the expense for purchase of new spikes, bolts, etc. Not one of the metal ties in this table, nor of the 124,000 steel ties in use on other lines of the Netherlands State Railroad Company, has broken in the track.

DISCUSSION.

E. E. Russell Tratman, Jun. Am. Soc. C. E.—Having received from Mr. J. W. Post, only a few days before the convention, the paper on "Maintenance Expenses of Track with Steel and Wooden Ties on the Netherlands State Railroad," which I have transmitted to the society by request of Mr. Post, I had not time to give as much attention as I would like to have done to this discussion.

The subject of metal railroad ties is one in which I take very much interest, and for some time past I have been engaged in making extensive investigations and collecting information with regard to practice and experience in foreign countries. In making my investigations I have been surprised at the great extent to which metal ties have been actually adopted for service, for while I knew that experiments had been made in many countries, in some cases on a quite extensive scale, I had no idea that, as a result of some of these experiments, many railroads had practically adopted these ties for regular use; this, however, I found to be the case, and several European railroad companies are now gradually substituting metal for wooden ties on their systems. I think few engineers who have not paid especial attention to this matter realize that metal ties are in actual service, the general impression seeming to be that while many experiments have been made and are still being continued, yet that no practical results have been obtained. To this lack of appreciation of the results of foreign experience may be attributed to a considerable degree, I think, the general track. (4) Ordinary steel rails on twelve timber ties per 9 meters of track, with alternating joints.

Between Weurne and Helmond the same four comparative trial lengths are being laid on ten, eleven, and twelve Post steel ties per 9 meters of track.

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E. E. Russell Tratman, Jun. Am. Soc. C. E.—Having received from Mr. J. W. Post, only a few days before the convention, the paper on "Maintenance Expenses of Track with Steel and Wooden Ties on the Netherlands State Railroad," which I have transmitted to the society by request of Mr. Post, I had not time to give as much attention as I would like to have done to this discussion.

The subject of metal railroad ties is one in which I take very much interest, and for some time past I have been engaged in making extensive investigations and collecting information with regard to practice and experience in foreign countries. In making my investigations I have been surprised at the great extent to which metal ties have been actually adopted for service, for while I knew that experiments had been made in many countries, in some cases on a quite extensive scale, I had no idea that, as a result of some of these experiments, many railroads had practically adopted these ties for regular use; this, however, I found to be the case, and several European railroad companies are now gradually substituting metal for wooden ties on their systems. I think few engineers who have not paid especial attention to this matter realize that metal ties are in actual service, the general impression seeming to be that while many experiments have been made and are still being continued, yet that no practical results have been obtained. To this lack of appreciation of the results of foreign experience may be attributed to a considerable degree, I think, the general indifference of American engineers to the question of metal track. The fact that the question of the future timber supply is one of serious import does not seem to be realized, although the reports of the forestry division of the United States Department of Agriculture show that use and waste are playing havoc with a supply that cannot, under the present system (or want of system) of forestry in this country, be renewed in proportion to the demand. It has always seemed to me surprising that American engineers, who are usually in the van of any great step in the profession, should have paid so little attention to this very important matter; important both as to the financial economy and the practical efficiency of the track. In my opinion steel ties should be used as the standard for first-class track, and not merely as a substitute for timber when the latter becomes scarce or expensive. For instance, on such a road as the projected New York and Boston Rapid Transit line, which is intended to be an independent line, and which will probably, when it materializes, start out with a heavy and rapid traffic, steel ties should be laid down in the first place. The same holds good for existing trunk lines, on which steel ties should be introduced, as an advancement in railroad engineering and a step towards economy.

Taken as a whole, the results of experience have been satisfactory, and the type which has been found to be the best is the cross-tie of the familiar reversed trough section. Cast-iron "bowl" sleepers are much used in new countries, and longitudinal iron sleepers are still used to some extent in Austria and Germany, but the cross-tie of trough section is the best type, as has been proved by experience and careful tests. In consequence this form of tie is being more and more widely adopted, numerous variations of section and various styles of rail fastenings being used, in accordance with the ideas of different engineers. In England several railroads are using steel cross-ties to a greater or less extent, but in consequence of the engineers keeping to the double-headed rail in chairs the track is very complicated and expensive, representing money wasted and lying idle in much useless metal, whereas with a good flange rail a metal track might be obtained more economical and more efficient than the present style of rails and chairs on wooden sleepers. Experience has shown that the ends should be closed, but in quite a number of cases open-end ties are used. With open ends, of course, the ties are more liable to lateral displacement, as they do not present the area of resistance presented by a wooden tie or a closed end.

As will be seen by Mr. Post's paper, the Netherlands State Railroad Company has made a systematic series of trials of different types of metal ties, and the very valuable and important result of these trials has been the designing of the mild steel rolled tie of trough section, with varying thickness, now well known as the "Post" tie, which has been adopted to a very considerable extent on European lines. Mr. Post has been fortunate in having charge of a road owned by a progressive and far-seeing corporation, which has grasped the economic purposes of metal track, and encouraged its engineer in his work of investigation. The comparisons of the different systems were gone into most thoroughly, account being taken of the amount of labor, time, and expense involved in maintenance, renewals, and repairs, and therefore Mr. Post has been able, gradually but steadily, to improve the form of tie, until he has arrived at the present form, which is correct in theory and successful in practice; it is easily manufactured, and has proved in service its advantages in point of economy and efficiency. The trouble experienced with early forms of ties was that they failed by cracking, generally between the holes for rail attachments, and if made thick enough to prevent cracking they were too heavy and expensive. With the "Post" tie the thickness is increased at the rail seat, giving ample strength where required, but without any undue excess of weight. This strengthening is secured in the operation of rolling by the use of special machinery, and in the same operation is secured the inclination of the ends which gives the rails an inward cant of one in twenty, in accordance with European practice. Many European steel works have orders on hand for "Post" ties.

The question of rail fastenings is one almost as important as that of the type of tie, and many different plans have been tried, some simple, but the majority very complicated. All riveting causes an extra expense, but a very favorite plan is to have a "clamp" or "crab" riveted to the tie to hold one side of the rail flange, the other side being held by a bolted clamp. Mr. Post, realizing that all extra shop-work is necessarily expensive, has adopted bolts exclusively, with entirely satisfactory results. It will be noted that the first type of metal tie experimented with had wooden blocks for the rails to rest upon, the idea being that the rail required an elastic seat. This seriously impaired the general efficiency of the tie, for the wood rotted and gave constant trouble, so that this form of tie was soon abandoned. It has been conclusively proved by experience with various types of ties in different countries that such a wood-bearing is not only unnecessary, but a positive disadvantage, and that the track is satisfactory to railroad men and travelers when the rail is fastened directly on the metal tie, and therefore no wood should be used at all, but a metal track should be entirely of metal. The introduction of metal ties has been hampered by the attempt to secure a "cheap" tie. The objects in using metal are to obtain economy in maintenance and efficiency in operation, and neither of these objects can be obtained by using a tie which is "cheap." Every desirable feature can not be combined in one piece of steel, and if the tie is to make the track safer, reduce the maintenance expenses, keep the road in better condition, and far outlast the wooden tie, it must have sufficient metal to insure these advantages. You need to have, and to pay for, enough metal to make an efficient tie; but you need not have, and need not pay for, extra metal that is mere dead weight. With ties, as with rails, the design and manufacture are equally as important points as the weight, and the rail fastenings no less important.

Two points need to be considered in designing or adopting a metal track, viz, economy and simplicity. Cheapness is very far from being economy, being in fact directly opposed to it. Simplicity is necessary, both for economy and efficiency, as the track which, while possessing ample strength, is the most simple in its construction, will give the least trouble, and consequently involve the least expense for maintenance. A good metal track, once well laid, is in itself a source of economy in maintenance and operation, and it is to be hoped that this type of track will soon be a feature of first-class American railroads.

In nearly every large country but America, and in many of the smaller countries, metal ties have been experimented with, and I would strongly urge that more practical attention should be paid to so important a matter by American engineers, railroad men, and steel manufacturers.

At the International Congress of Railroads, September 17 to 24, 1887, the following resolutions were the outcome of its discussions:

(*a*) The opinion of the Brussels Congress that iron ties are of equal value to wooden, has not been negatived during the last two years; the application of iron ties is rather on the increase.

(*b*) The question whether the use of wood or metal ties is cheaper depends on the local conditions and the state of the iron market.

(*c*) Regarding cost of maintenance and renewal, not yet sufficient data are on hand for lines with large and rapid traffic; for medium traffic and slow trains the iron ties offer advantages, especially when after some time the track has consolidated and the fastening has settled well.

(*d*) For the "Vautherin" form the use of a homogeneous metal is desirable.

PATENTS RELATING TO METAL RAILWAY TRACK.

By E. E. Russell Tratman.

The following list of United States patents relating to metal railway track will be found useful by persons interested in this subject. It could not practically be made anything more than a descriptive index, giving sufficient information to enable any one who wishes to investigate more fully to find the specifications.

No. 1,262; date, July 26, 1839; J. Stimpson.—Transverse frames resting on longitudinal timbers, with inclined braces to hold them in position, and sockets at the top to receive the web of a rail with a very narrow flange.

No. 16,898; date, March 24, 1857; H. Carpenter.—A short hollow post under each rail, connected by a tie-plate; T-shaped fastening fitting into hollow of post.

No. 18,494; date, October 27, 1857; S. A. Beers.—Continuous longitudinal structure with transverse tie-plates. Saddle rail of ⎍ section.

No. 19,704; date, March 23, 1858; S. H. Long.—Cross-ties of channel ⊓ section or T section (the latter made of two angle irons). Continuous flat plate under ordinary rail.

No. 20,620; date, June 22, 1858; W. Bryent.—Combined longitudinal grooved rail and iron pavement.

No. 32,794; date, July 9, 1861; B. C. Smith.—Wide longitudinal channel sleeper and rail combined, with transverse rods. A raised rib lengthwise of the sleeper forms the rail.

No. 36,579; date, September 30, 1862; B. C. Smith.—Longitudinal cast-iron continuous bearing, of channel section, connected by transverse tie-rods. Rail secured to chairs.

No. 53,507; date, March 27, 1866; Franz Vester.—Flat cross-tie, with two deep corrugations along its whole length. Ends turned down.

No. 66,711; date, July 16, 1867; R. M. Holland.—Cross-tie of Λ section. Flange cut away for rails. Hinged wedge fastening.

No. 70,731; date, November 12, 1867; Henry McCan.—Broad flat transverse base-plates, with longitudinal girders held together by tie-rods. Rails resting on top of girders.

No. 71,063; date, November 19, 1867; Leonard Repsher.—Wrought-iron flat cross-tie, bent up at ends to embrace flange and web of rail, angle-clamp bolted to tie on inside of rail. Bolt through clamp, web of rail, and end of tie.

No. 83,880; date, November 10, 1868; J. Potter.—Flat transverse base-plate, with two uprights which support continuous stringers, to which flangeless T-rails are bolted.

No. 109,504; date, November 22, 1870; C. Fisher.—Cross-tie of inverted trough section, with closed ends. Two pockets for wooden bearing-blocks. Rail fastened by flat plates resting on tie and rail flange, screwed to the wooden blocks.

No. 112,805; date, March 21, 1871; S. M. Guest.—A railway joint chair, combined with an iron cross-tie of T section.

No. 121,956; date, December 19, 1871; J. Newton.—A rail fastening for iron ties. Flat tie with end turned up; wooden wedge between rail and end of tie; vertical gib and cotter fastening (with serrated cotter) on inside of rail.

No. 123,526; date, February 6, 1872; L. E. Towne.—Cylindrical cross-tie with a flat base plate at each end, and a rail chair on top at each end, secured by a strap passing round the tie.

No. 124,521; date, March 12, 1872; R. M. Upjohn.—Longitudinals under each rail, of ⊥ section with very high vertical web. The rail is of _⊓_ section and rests upon the flanges of channel irons bolted to the vertical web of the longitudinals.

No. 134,418; date, December 31, 1872; James Calkins.—The continuous longitudinals of channel sections have lugs to hold the outer flange of rails; transverse plates project over the inner flange and are bolted to the longitudinals.

No. 136,067; date, February 18, 1873; J. W. Kern.—A continuous roadbed of Λ section, with the rails laid on the horizontal flanges. Transverse base plates at intervals. The bed to be of ¼-inch boiler-iron.

No. 139,518; date, June 3, 1873; W. Peck and H. C. Richman.—Two chairs connected by a horizontal flat tie-plate. Wooden bearing-blocks in the chairs.

No. 140,411; date, July 1, 1873; C. W. Gulick.—A flat wrought-iron cross-tie with ribs to form a channel for the flange of the rail. Fastenings of iron $\frac{4}{10}$ inch diameter under tie, passing up through holes in the same, with ends bent over rail flange. Ties about 5 inches wide and ½ inch thick.

No. 143,407; date, October 7, 1873; P. S. Devlan.—A cross-tie made of two iron plates on edge, fastened together at the middle and widening out to hold a wooden block at each end.

No. 144,207; date, November 4, 1873; George Keech.—Longitudinal plates under each rail, with lugs to hold outside of rail flange. Tranverse tie-plates project over the inner flange and are secured by horizontal bolts passing through lugs on the base plate.

No. 145,991; date, December 30, 1873; H. L. De Zeng.—Wrought-iron cross-tie of ⊓, ‾∪‾ ‾∪‾, or other section. A clip stamped out of the metal holds outer flange of rail; loose clip secured by vertical key or cotter holds inner flange. (See 155,369.)

No. 146,376; date, January 13, 1874; G. H. Blaisdell.—A cast-iron cross-tie of Λ section with wide, flat, deep ends, having sockets for wooden blocks. A bolt passes through both blocks and the whole length of the tie.

No. 147,563; date, February 17, 1874; P. Kendrick and J. Stokes.—A cross-tie made of two old rails laid parallel, with a wooden block between them at each end, and base plates if desired.

No. 148,242; date, March 3, 1874; George Potts.—Continuous bearing of wood held between two continuous iron stringers of ⊥ section, the top of the web being bent over to hold the rail flange. Bolts pass through the three pieces.

No. 155,369; date, September 29, 1874; H. L. De Zeng.—A cross-tie of inverted trough section, with open ends, but with projecting wings at ends to prevent lateral displacement. See No. 334,696.

No. 163,187; date, May 11, 1875; S. H. Hamilton.—An iron or steel cross-tie of square hollow section throughout, or only at ends. Fixed lugs hold the inner flange of rail, and bolted plates hold the outer flange.

No. 163,254; date, May 11, 1875; H. Reese.—A rolled iron cross-tie of T section; lugs stamped out while hot from the rolls. Bent clip and horizontal wedge fastening for outer flange of rail. (See 214,192.)

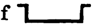
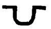
No. 164,793; date, June 22, 1875; Ramon Bañolas.—Cross-ties of I section, carrying longitudinal stringers of ⊥ section, to which flangeless rails of ┐ section are bolted.

No. 166,625; date, August 10, 1875; R. E. Nichols.—A continuous hollow bearing, section similar to lower half of letter A; bottom closed; top open, with horizontal flanges to carry the rail flange; cross-ties of └┘ section. Longitudinals and cross-ties filled with broken stone.

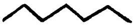
No. 171,422; date, December 21, 1875; John Quigley.—A cast-iron cross-tie with chair combined, for street railway track.

No. 172,041; date, January 11, 1876; E. E. Lewis.—A cross-tie of + section, with the top vertical flange cut away for the rails, which are secured by wedges. (See 183,766.)

No. 176,213; date, April 18, 1876; George D. Blaisdell.—A cast-iron cross-tie, with wide ends and loose bearing blocks, all held together by a bolt running through the whole length of the tie.

No. 182,984; date, October 3, 1876; Leonora E. Yates.—Cross-ties of , , or  section, the latter being semi-cylindrical, with flanges. The rails are fastened by bolted clamps.

No. 183,766; 183,767; 183,768; date, October 31, 1876; E. E. Lewis.—A cross-tie of + section; rails of different forms. Also a joint tie of ⊥⊥ section. (See 172,041.)

No. 185,808; date, December 26, 1876; D. S. Whittenhall.—A cross-tie of  section; the rails resting in notches in the top ridges.

No. 188,087; date, March 6, 1877; H. S. Wilson.—A cross-tie of I section, with fixed and movable rail clips.

No. 188,710; date, March 20, 1877; N. S. White.—A continuous bed-plate under each rail, with cross-ties.

No. 190,739; date, May 15, 1877; A. H. Campbell.—A cast-iron cross-tie, with sockets for wooden bearing-blocks.

No. 192,842; date, July 10, 1877; A. W. Serres.—A continuous bearing of section (in two pieces) under each rail, with transverse tiè-bars. The web of a flangeless rail lies between the two vertical webs. (This track has been used in Europe. See Engineering News, New York, January 29, 1887, page 73; also Railroad Gazette, New York, August 19, 1887.)

No. 198,060; date, December 11, 1877; John B. Ward.—A longitudinal iron pipe (for conveying water) under each rail; the bottom of rail curved to fit pipe.

No. 198,464; date, December 25, 1877; E. E. Lewis.—A cross-tie consisting of an old rail with two notches cut to the level of the flange to admit the track rails. Two rails with wooden bearing-blocks used at joints. (See 172,041.)

No. 198,618; date, December 25, 1877; D. Horrie.—A transverse truss of cast or wrought-iron. Horizontal hook-bolt fastenings.

No. 201,667; date, March 26, 1878; H. A. Haarmann.—Continuous bearing for each rail, with cross-ties. This track has been extensively used in Europe. (See Engineering News, New York, January 29, page 74.) (See 219,856.)

No. 206,647; date, July 30, 1878; T. W. Travis.—A hollow cross-tie, with boxes at the ends open on top. The rails are held between two ⊏ clips; the groove holds the rail-flange; the upper web lies against the rail web, and the lower web is wedged into the box.

No. 207,242; date, August 20, 1878; J. A. Bonnell.—An inverted trough cross-tie, with closed ends and corrugated top. Bolted clips or angle-bar fastenings for rails.

No. 207,320; date, August 20, 1878; J. H. Thompson.—A cross-tie made in two pieces, dove-tailed together in the middle. The rails rest on wood blocks.

No. 207,719; date, September 3, 1878; W. E. Curtiss.—A wrought-iron cross-tie of inverted trough section with flaring sides, having a brace of the same section inside under each rail. The ends are open. Rails secured by bolted clips.

No. 210,774; date, December 10, 1878 (patented in Germany, January 18, 1878); F. B. Freudenberg.—A wrought-iron cross-tie of somewhat similar section to the preceding one. Hooked clips are riveted on for the inside and outside flange on alternate ties, the rails being sprung into place. Long ties for double tracks.

No. 214,192; date, April 8, 1879; H. Reese.—A cross-tie of T section, with the ends of the horizontal table turned down at an angle. Clip and wedge fastening. (See 163,254.)

No. 215,675; date, May 20, 1879; H. Reese.—Improvements upon the preceding one.

No. 216,846; date, June 24, 1879; L. A. Gouch.—A cross-tie of ─┼─ section, the longitudinal web being the widest and having its edges turned up or down.

No. 218,559; date, August 12, 1879; S. Nicholls (of England).—A continuous broad bed-plate under each rail, for street railways. The rail is formed of two channels, leaving a space between for the wheel flange ⊐ ⊏.

No. 218,603; date, August 12, 1879; A. P. Whiting.—A cross-tie of ⊢⊣ section, the top flange cut away for the rails. Bolted clips hold the inner flanges of rails.

No. 218,643; date, August 19, 1879; C. F. Wagner (of Austria).—A cross-tie composed of two parallel pieces of T section, fastened together by cross-strips. Bolted clip rail fastenings.

No. 218,873; date, August 26, 1879; C. Hanshaw.—A cross-tie made in two pieces lengthwise; on one piece are clips for the inner flange of one rail and the outer flange of the other, and on the other piece are clips for the outer and inner flanges, respectively. The two pieces are held together by a flat horizontal key driven between other clips in the middle of the tie.

No. 219,856; date, September 23, 1879; H. A. Haarmann, of Prussia, (see No. 201,667).—A cross-tie of inverted trough section with flaring sides, and a flat or grooved top table. The rail fastenings are ⊏-shaped, with a bolt passing under the rail.

No. 220,026; date, September 30, 1879; H. T. Livingston.—A tubular cross-tie of oval section with a flat surface under each rail. Rails fastened by bolts screwed into the tie. Interior of tie packed hard with straw, grass, etc.

No. 221,596; date, November 11, 1879; O. E. Mullarky.—A cross-tie of channel section ⊓ with wooden bearing blocks wedged inside under the rails. The rails are fastened by bolted clips.

No. 223,187; date, December 30, 1879; J. R. Sullivan.—Two separate cast-iron bearing pieces connected by a tie-bar. Each rail is secured by a cast-iron wedge.

No. 226,308; date, April 6, 1880; A. Greig (patented in England March 25, 1879).—Flat cross-ties with one or two grooves along the whole length. A brace or clip is riveted to hold the outside of the rail, and the rail is held against it by a hook bolt, the body of which lies in the groove and has a nut at the end of the tie. (This system is much used for portable railways manufactured in England.)

No. 227,602; date, May 11, 1880; D. S. Whittenhall.—Improvements on No. 185,808.

No. 9,292 (re-issue); date, July 13, 1880; H. Reese.—See original number 214,192 of April 8, 1879.

No. 230,826; date, August 3, 1880; Lewis Scofield.—A cross-tie of ⊓ section. Riveted and bolted clips for rail fastenings.

No. 231,755; date, August 31, 1880; William Brown.—A hollow cross-tie of rectangular section, with concave bottom and open ends. A rib at the ends keeps the rail in position, and it is fastened down by hooked bolts with nuts inside the tie.

No. 233,528; date, October 19, 1880; W. C. Lutz.—A cross tie of ⊥ section, with the rails secured by flat hooked clips bolted to the side of the vertical web. (See 241,389.)

No. 235,078; date, December 7, 1880; G. H. Gilman.—A cast-iron cross-tie of rectangular section, with grooves to reduce the weight. The rails are held by fixed and movable lugs.

No. 235,321; date, December 7, 1880; F. A. Williams.—The two broad bearing plates on which the rails rest are connected by two transverse tie-plates, placed on edge.

No. 240,937; date, May 3, 1881; I. W. Fleck.—A cross-tie made of an ordinary rail, head down, with strengthening sections and a broad base plate bolted to it. It is curved into an arch form, high in the middle, with the ends level for the track rails.

No. 241,389; date, May 10, 1881; W. C. Lutz.—A cross-tie of cylindrical form, with flat-bearing surfaces for the rails; or with a vertical web on top, with notches for the rails. (See 233, 528.)

No. 242,850; date, June 14, 1881; H. Thielsen.—Cross-tie of T section; in two halves, one under each rail. Bent clips formed out of the metal of the tie. The two pieces keyed together at the middle. (See 317,244.)

No. 246,888; date, September 13, 1881; G. A. Jones.—A cross-tie of ⊥ section with the ends formed into a chair. The rail is held in the chair and spiked to a wood block.

No. 247,248; date, September 20, 1881; Levi Haas.—A cross-tie made of an old rail with the ends resting on wood blocks; the track rails are secured to the top of the tie. (See 257,572.)

Nos. 249,270, 249,271; date, November 8, 1881; E. H. Tobey.—Cross-ties of ⊔ or V section; the rails are held in chairs resting on wooden blocks.

No. 249,503; date, November 15, 1881; J. Clark.—A cross-tie of semicircular section ⌓, the bottom fastened to a flat bed-plate the whole length of the tie. The top of the arch cut away for the rail. (See 256, 199, 259, and 095.)

No. 251,251; date, December 20, 1881; C. F. Kreuz.—A flat cross-tie with thickened ends to hold the outer flanges of the rails; and a flat cross-tie with another flat piece resting on it to hold the inner flanges of the rails. These ties placed alternately. (See 263, 919.)

No. 254,802; date, March 14, 1882; J. Conley.—A flat cross-tie in two pieces, with the inner end of each turned up so as to be bolted together. Under the rails the sides are turned down. Clips are stamped out of the metal. (See 332, 384.)

No. 255,554; date, March 28, 1882; F. A. Williams.—A cross-tie of shallow inverted trough section, with broad ends. The rails are held against fixed clips by plates the whole length of the tie, placed on edge, underneath, with a hooked end to hold the rail flange. These plates are secured by a horizontal key in the middle of the tie.

No. 256,199; date, April 11, 1882; J. Clark.—Improvements upon No. 249,503.

No. 257,437; date, May 2, 1882; H. De Zavala.—A cross-tie of Λ section, with U bolts passing under the rail and having nuts screwed down on the rail flange.

No. 257,572; date, May 9, 1882; Levi Haas.—A cross-tie consisting of two cast-iron bed-plates, with bearing blocks to which the rails are bolted. A tie-bar connects the two bed-plates.—See No. 247, 248, 315, 771, 389, and 464.

No. 259,095; date, June 6, 1882; J. Clark.—Further improvements on Nos. 249,503 and 256,199. (See 270, 637; also August 5, 1884, and 358, 144.)

No. 259,823; date, June 20, 1882; A. L. Cubberlery.—A flat cast iron cross-tie, with concave bottom, and dove-tail grooves on top for sliding rail-fastenings into place.

No. 259,891; date, June 20, 1882; J. H. Meacham.—A cross-tie of ⊥ section, with end boxes for wood blocks, to which the rails are secured by hook bolts.

No. 260,231; date, June 27, 1882; J. Parr.—A cast-iron cross-tie with fixed and movable lugs for the flanges of the rails. (See 277,333.)

No. 263,919; date, September 5, 1882; C. F. Kreuz.—A cross-tie of H section, the rails resting on the web and secured by wedges. An improvement on No. 251,251.

No. 265,760; date, October 10, 1882; M. I. Cortright.—A cross-tie with two grooves or corrugations in its length, and with notches to receive the flange of the rails.

No. 267,930; date, November 21, 1882; G. L. Putnam.—A cross-tie of square section, hollow or solid, with hooked spikes put in place from the bottom and tapering upwards. (See 285,842.)

No. 269,442; date, December 19, 1882; R. B. Meeker.—Cross-ties of T section, with broad table. Flat horizontal bars with turned-up ends, used alternately with the ties. The rail to be of extra height, bolted to chairs

No. 270,637; date, January 16, 1883; J. Clark.—A flat cross-tie with arched bearing plates and chairs. See No. 259,095.

No. 272,850; date, February 27, 1883; T. Breen.—A flat cross-tie twisted spirally in the middle and having the ends turned up. (See 294,191.)

No. 274,309; date, March 20, 1883; W. H. Gibbs and George Snook.—A cross-tie of ⊥ section, with supports for a rail-chair of inverted-trough section, with a wooden block, to which the rail is secured by hooked clamps.

No. 276,414; date, April 24, 1883; E. B. Hungerford.—A cross-tie of shallow channel section ⊔. The flanges are cut away and notched to hold the rail-flange, and the rail rests on a loose bed-plate with a clip to hold the other flange; the plate being held in place by a horizontal key driven through holes in the tie-flanges.

No. 277,333; date, May 8, 1883; J. Parr.—A hollow cast-iron cross-tie. The rails are secured to loose chairs, having long projections which run nearly through the tie and are secured by a vertical bolt at the middle of the tie. (See No. 260,231.)

No. 280,110; date, June 26, 1883; S. B. Wright—A cross-tie of inverted-trough section, with the inside of the top arched. (See 298,539.)

No. 280,200; date, June 26, 1883; J. Mahoney and D. W. Shockley.—A cross-tie of ⊥⊥ section, with wooden bearing-blocks. (See No. 370,634.)

No. 281,806; date, July 24, 1883; A. R. Spaulding.—A cross-tie of channel section ⊓ to which the rail is fastened by a series of flat horizontal keys or wedges in dove-tailed grooves.

No. 283,076; date, August 14, 1883; J. L. Chapman.—Cross-ties of shallow channel ⊔, or of two flat plates, one above the other, separated by distance-blocks. Each rail is secured by bolted clips to a bed-plate.

No. 283,230; date, August 14, 1883; H. F. Flickinger.—A cross-tie of I section, to which the rails are secured by ∩ bolts with the nuts on the under side of the top flange of the tie.

No. 284,157; date, August 28, 1883; J. W. Young.—A hollow, open-sided, elastic cross-tie of ⊐ section; to be filled with ballast or earth on surface lines. Two or more of these plates to be placed inside one another, with one side open, or to form a closed tie. It is claimed to be adapted to elevated roads.

No. 285,833; date, October 2, 1883; John Newton.—Channel-iron stringers ⊓ with flat cross-ties fastened to the top.

No. 285,842; date October 2, 1883; George L. Putnam.—A cross-tie of T section, depressed in the middle to hold a water-trough for supplying locomotives. The rails are secured by bolted clips. See No. 267,930.

No. 285,986; date, October 2, 1883; Clark Fisher.—A bent-plate cross-tie, of ∩ section in the middle, with flat ends. A U bolt passes under the rail, and washers are screwed down on the rail flange by the nuts.

No. 287,418; date, October 30, 1883; J. J. Clarke (of Peru).—A flat plate tie for portable railway track, with special joint fastenings. (Assigned to A. W. Colwell, New York.)

No. 289,806; date, December 11, 1883; T. J. Bronson and A. Armstrong.—An iron or steel cross-tie of approximately semi-cylindrical section ∩, with lugs struck up by means of dies.

No. 290,793; date, December 25, 1883; L. O. Orton.—A flat inverted trough cross-tie, with wedge-shaped boxes projecting above and below to hold the bearing blocks and fastenings.

No. 291,514; date, January 8, 1884; H. R. Holbrook.—A hollow cross-tie of oval section, with thickened portions under the rails; rails secured by bolted clips.

No. 292,421; date, January 22, 1884; J. J. Du Bois.—A cross-tie, with dove-tailed groove for rail and a wedge fastening.

No. 293,194; date, February 5, 1884; J. Reven.—A flat tie-bar to keep rails from spreading; one end bent up to hold rail, the other end having thread and nut, with movable clamp.

No. 293,302; date, February 12, 1884; George W. Bloodgood.—Bolted clips for fastening rails to ties of inverted-trough section.

No. 294,191; date, February 26, 1884; T. Breen.—A cross-tie made in two pieces, lengthwise; placed side by side, holding the rail-chairs and fastenings between them. (See 272,850.)

No. 296,725; date, April 15, 1884; W. T. Carter.—A hollow cross-tie, with flat top and bottom and concave sides.

No. 298,539; date, May 13, 1884; S. B. Wright.—Fastening rails to inverted-trough cross-ties by clips and T-headed bolts. (See No. 280,110.)

No. 299,557; date, June 3, 1884; J. Lockhart.—A clamp or tie-rod, to be used in connection with wooden ties. A tie-rod, running across the track, has clamps to hold the rail flanges, the inner clamps being held by set-screws. It is claimed that soft-wood ties can be used, as there will be no tendency for the rails to spread. (See 327,285.)

No. 302,965 and No. 302,966; date, August 5, 1884; C. S. Westbrook.—A cross-tie of ⊓ section, with parts of the horizontal table cut away. The rails are held by riveted and keyed angle plates.

Nos. 10,504, and 10,505 (re-issues); date, August 5, 1884; J. Clark.—Improvements in No. 249,503.

No. 303,373; date, August 12, 1884; E. G. Holtham (of England). Patented in England, December 22, 1883.—Broad longitudinals under each rail, with transverse tie-rods, and with additional side plates to increase the bearing on the ballast.

No. 304,746; date, September 9, 1884; G. W. B. Neal.—A cross-tie made of triangular section, with the rails carried in and bolted to chairs fastened to the apex of the tie.

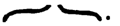
No. 306,090; date, October 7, 1884; Robert Moffly.—A cross-tie made of three pieces the full length of the tie, bolted together so as to form a ⊥ slot along it, in which the rail fastenings slide.

No. 306,139; date, October 7, 1884; B. W. De Courcy.—A cross-tie of section, with the rails resting on the top and secured by hooked clamps bolted together below the rail.

No. 309,428; date, December 16, 1884; J. H. Williams.—A cross-tie of U section, with wooden blocks to which the rails are spiked.

No. 310,269; date, January 6, 1885; Abraham Gottlieb.—A cross-tie of inverted-trough section, with a groove along its top table. The rail is fastened by bolted clips or a special form of locking-plate or chair.

No. 312,566; date, February 17, 1885; W. H. Knowlton.—Cross-ties of different sections.

No. 312,717; date, February 27, 1885; E. N. Higley.—A flat cross-tie with sides and ends turned down and with a vertical rib along the middle. This rib cut away for the rails, which are fastened by bolted clips. General section thus, . See No. 334,228. (Manufactured by the International Railway Tie Co., of New York. See Appendix B of report on metal track.)

No. 312,881; date, February 24, 1885; W. McVey.—A metal cross-tie in two pieces, mortised together at the middle and secured by a bolt.

No. 313,072; date, March 3, 1885; A. A. Harrison.—A combined flat longitudinal and cross tie; the cross-tie having plate at right angles and being laid so that these plates of adjacent ties meet.

No. 314,757; date, March 31, 1885; C. H. Van Orden.—A cross-tie of T section, with a rail chair at each end, the rails being secured by bolts which have hooked ends passing through the top of the tie.

No. 315,047; date, April 7, 1885; M. A. Martindale.—Longitudinals of inverted-trough section with rails forming a part of or bolted to the top table. Connected by transverse tie plates. Claimed to be adapted for laying along highways.

No. 315,771; date, April 14, 1885; L. Haas.—A cross-tie made of two pieces the full length of the tie, with the section of figure 1, having wooden-bearing blocks to which the rails are spiked. See No. 257,752.

No. 317,244; date, May 5, 1885; H. Thielsen.—A cross-tie of T section, the sides of the top table being turned down. (See No. 242,850.)

No. 317,763; date, May 12, 1885; M. A. Glynn (of Cuba).—Cross-ties of or ⊥ section; also longitudinals of inverted trough section.

No. 319,010; date, June 2, 1885; A. J. Moxham.—A cross-tie made of two angle-irons, with distance-plates at the ends and middle ┌─ ─┐; the rails are bolted to high chairs. The tie is intended for street railways, and is shown with a center-bearing girder-rail.

No. 319,813; date, June 9, 1885; G. C. H. Hasskarl.—A hollow box cross-tie, with a Y-shaped web inside; the small middle space receiving the T heads of the track-bolts. It is also to be used as a longitudinal sleeper for street railways, the two large side spaces being used as conduits for telegraph wires, etc.

No. 320,231; date, June 16, 1885; E. D. Dougherty and George B. Bryant.—A cross-tie of rectangular section, with an opening in the top table to receive a smaller cross-tie to which the rails are fastened, and which rests on springs placed in the larger box.

No. 323,356; date, July 28, 1885; G. Murray.—A flat cross-tie thickened under the rail, and having a rib at the bottom under each rail, and in the middle; the rails secured by bolted plates.

No. 323,430; date, August 4, 1885; J. K. Lake.—A combined metal stringer and chair for street railways.

No. 323,809; date, August 4, 1885; William B. Henning.—A longitudinal plate lies under each rail; with cross-ties having deep ends with ⊥ slots to receive the web and flange of the rails. (See 376,884.)

No. 325,020; date, August 25, 1885; R. R. Shepard.—A cross-tie of channel section ⊓ with one outer and one inner lug for each rail, and two ┌ slots for clips of ⊏-shape with eccentric heads.

No. 326,874; date, September 22, 1885; P. Kirk (of England).—A cross-tie with increased thickness at the rail seats, and with two lugs or clips punched up to hold the flange of each rail; the rail being secured by a wedge driven between the flange and one of the lugs (patented in England, France, Belgium, and Spain, in 1885).

No. 327,285; date, September 29, 1885; J. Lockhart.—An improvement upon No. 299,557.

Nos. 327,745 and 327,843; date, October 6, 1885; L. E. Whipple.—A cross-tie of X section, made of two curved plates placed back to back and having flat plate across top and bottom.

No. 328,632; date, October 20, 1885; J. S. Ammon.—A cross-tie of Λ section with rail chairs secured to the top ridge.

No. 329,429; date, November 3, 1885; G. E. Baldwin.—A pair of rail chairs of _∩_ shape, resting on wooden blocks and tied together by a rod. The top table has a groove to receive the web of a rail of T section, having no bottom flange. Intended especially for city railways.

No. 329,821; date, November 3, 1885; P. Davey.—A cross-tie of channel section, to which the rails are secured by keys and Z-shaped clamps, the lower part of the latter lying inside the tie.

No. 332,384; date, December 15, 1885; J. Conley.—A fastening for attaching rails to metal ties, which have lugs to hold the outer flange of rail. The fastening is a bar inside the tie, with a hook at one end projecting through a hole and holding the rail flange, while the other end is bent up against the end of the tie. (See 254,802.)

No. 333,015; date, December 22, 1885; J. Howard and E. T. Bousfield (of England).—A cross tie of ⌒ section, with a U-shaped depression for each rail, the rail being secured with a wooden wedge. (These ties have been used with the English double-headed rail; patented in England.) (See 335,523.)

No. 333,480; date, December 29, 1885; L. B. Prindle.—A steel cross-tie three-eighths to one inch thick; channel section ⊓; at each end is a slot to receive a tenon at the bottom of a rail chair.

No. 334,228; date, January 12, 1886; E. N. Higley.—An improvement on No. 312,717. (See 353,028.)

No. 334,696; date, January 19, 1886; H. L. De Zeng.—An improvement in fastenings. (See Nos. 145,991 and 155,369; also 380,623.)

No. 335,523; date, February 2, 1886; J. Howard and E. T. Bousfield (of England).—A cross-tie made of a metal sheet or plate, with one or more corrugations lengthwise, the rails being held in chairs made by cutting away the corrugations. (See No. 333,015.)

Nos. 335,804 and 335,805; date, February 9, 1886; E. P. J. Freeman.—A cross-tie made of a sheet of metal bent to form a rectangular box. A wooden block is placed inside, under each rail, and a spike is driven into the wood through a hole in the metal. The spike may be split so as to flare like Λ when driven in combination, a guard-rail of a plate bent to Z shape, the rail lying on the bottom flange and all fastened to the tie.

No. 338,057; date, March 16, 1886; J. Gearon.—A continuous road-bed made of channel cross-ties placed alternately ⊓ and ⊔, with the vertical flanges overlapping one another.

No. 339,275; date, April 6, 1886; J. DeMott.—A cross-tie with a rail chair at each end. The end of the tie is rounded on plan, and is embraced by a ⊂ clamp with the ends turned up to hold the rail flange.

No. 339,938; date, April 13, 1886; F. F. Scott.—A cross-tie with a chair for each rail; one half of chair fixed, the other fastened by bolts. Pins driven through the web of the rail prevent vertical movement.

No. 340,118; date, April 20, 1886; H. Howard.—A deep channel ⊔ cross-tie for street railways. The rails are keyed to chairs resting on the top of the flanges.

No. 341,416; date, May 4, 1886; F. V. Greene.—For street railways. A continuous cast-iron hollow bearing (preferably 10 feet long and weighing 140 pounds per yard) under each rail. The rails are grooved, and are screwed to the top of the longitudinal.

No. 342,987; date, June 1, 1886; A. N. Warner and T. J. Deakin.—A cross-tie of channel section ⊔ with T-shaped rail chairs fitting into it. The rail secured to chairs by bolts with hooked ends, the nuts being under the flange of the chair.

No. 344,011; date, June 22, 1886; C. H. Sayre.—Flat or arched ⌒ cross-ties with pieces punched out of the top and bent to embrace the flange and web of the rail.

No. 344,185; date, June 22, 1886; W. Kilpatrick.—A cross-tie of ◡ section, with a slot along the flat top to receive the bottom of the rail chairs.

No. 344,826; date, July 6, 1886; I. F. Good.—A flat cross-tie thickened and widened at the ends to form rail chairs, and having flanges projecting down under the chairs. The rails secured by keys.

No. 345,733; date, July 20, 1886; C. Sailliez.—A cross-tie of channel section ⊓, with lugs to hold the rail flanges. The flanges are cut away at the ends to allow of wooden stringers being used under the rails.

No. 346,998; date, August 10, 1886; D. Kaufman.—Flat cross-ties with chairs at the ends, and longitudinal continuous flat plates beyond the chairs. The space between the rails is covered by a continuous arched plate.

No. 349,524; date, September 21, 1886; E. Schmidt (of Prussia).—A cross-tie made of two old flange rails laid flat, head to head, forming a tie of H H section. The rails rest on the web and are fastened by bolted clips. (Patented in Germany.)

No. 350,692; date, October 12, 1886; T. L. Mumford and H. Moore.—A cross-tie of inverted trough section, wider at the ends, with fixed lugs and movable clamps for fastening the rails.

Nos. 351,498 and 351,499; date, October 26, 1886; E. C. Davis.—A cross-tie made of two old rails placed side by side. Each track rail rests on a bearing-block in two pieces, with a lip at the end to engage the rail flange. The blocks are slid into place between the tie-rails and bolted through the tie.

No. 352,602; date, November 2, 1886; E. F. Reynolds.—A cross-tie of IΛΛI section. The rails rest in notches cut in the top, and are held by hinged clips and locking clips.

No. 353,028; date, November 23, 1886; E. N. Higley.—Improvements upon Nos. 334,228 and 312,717.

No. 353,691; date, December 7, 1886; S. D. Locke.—A channel cross-tie ⊓, with inclined ends and a transverse rib in the middle. The rails are fastened by bolted clips. (See 356,002.)

No. 354,250; date, December 14, 1886; R. S. Sea.—A cross-tie of T section with enlarged ends forming rail chairs. (See 379,005.)

No. 354,433; date, December 14, 1886; R. Morrell.—A cross-tie made of a plate bent to form a hollow rectangular box, with the top and bottom cut away at the middle. The rails are fastened to wooden bearing-blocks placed inside the tie. (See 365, 932.)

No. 356,002; date, January 11, 1887; S. D. Locke.—An improvement on No. 353,691.

No. 358,144; date, February 22, 1887; J. Clark.—A cross-tie of channel section, with chairs for the rails. (See No. 249,503, etc.)

No. 358,981; date, March 8, 1887; J. C. Lane.—An iron bridle-rod, made in two pieces, bolted together at the middle, to prevent rails from spreading at the curves.

No. 359,115 and No. 359,117; date, March 8, 1887; W. Wharton, jr.—A cross-tie of ⊥ or L section, with the bottom flange bent up to make a chair for the rails. To be used on street railways with girder rails.

No. 359,440; date, March 15, 1887; T. Gleason.—A cross-tie of trough section ⊔, with interior cross-pieces or webs to which the rail clamps are fastened.

No. 360,397; date, March 29, 1887; M. Y. Thompson.—A flat cross-tie, with a U shaped depression at each end to receive a wooden bearing-block. The rails are fastened by keys.

No. 361,199; date, April 12, 1887; H. P. Adams.—A cross-tie of T section, with chairs keyed to it.

No. 361,330; date, April 19, 1887; P. J. Severac, of Paris.—A cross-tie of I section, with the horizontal flanges bent at the ends. In some cases a broad plate is riveted to the bottom flange. The rails are fastened by clips or keyed to chairs. (This system is in use in Europe.) Patented in France, Belgium, England, Italy, and Spain, in 1884–'85.

Nos. 362,786 and 362,787; date, May 10, 1887; J. Riley (of Scotland).—A cross-tie of inverted trough section, with the rail chairs stamped or pressed by dies, the rails being secured by wedges. (Patented in England and Belgium; 1885–'86).

No. 363,020; date, May 17, 1887; L. Taylor.—A hollow-box cross-tie, with outward-flaring sides and concave bottom. The rails are fastened by hook bolts with the nuts inside the tie.

No. 365,350; date, June 21, 1887; A. Roelofs.—A cross-tie of channel ⊓ or inverted trough section. The rails are fastened by fixed lugs on the outside, and a tie-bar which is sprung into place on the inside. Also a flat tie with a rib under each rail and a slot along the middle for the bent tie-bar.

No. 365,511; date, June 28, 1887; F. X. Georget.—A cross-tie or longitudinal, of channel section ⊔, built up of a base plate and two concave side plates with the tops flanged outward horizontally. The ties or longitudinals are connected by tie rods. (See 381,125.)

Nos. 365,932 and 365,933; date, July 5, 1887; R. Morrell.—A hollow cross-tie, made of a plate bent to an oblong section, with straps around it at the rail fastenings. The metal is cut away to let the rails rest on a wood block inside the tie; the metal straps keep the spikes from working loose and allowing the rails to spread. Also a tie for elevated roads, made of two plates on edge, fastened together at the middle, and flaring apart to admit wooden bearing-blocks between them. See No. 354,433.

No. 366,546; date, July 12, 1887; N. S. White.—A cross-tie of channel ⊓ or inverted trough section, with a base plate at each end, with a bearing-block of wood or other material inside under each rail. The rails are fastened by locking clamps.

No. 367,325; date, July 26, 1887; John Splane.—A cross-tie of ⊓ channel section, with the bottom of the sides flanged outwards. The rails are let into apertures in the top and rest on the hooked ends of two tie-bolts, the inner ends of which are connected by a turnbuckle which is tightened by a wrench, there being a hole in the middle of the top table of the tie.

No. 367,383; date, August 2, 1887; J. Fitzgerald.—The rails are fastened to a cast-iron cross-tie by hook-headed spikes, which are secured by horizontal keys fitting into corresponding notches in the tie and spike.

No. 369,591; date, September 6, 1887; J. H. Coffman.—A solid tie with a groove along the top and lugs for the inner flanges of the rail; hooked rods hold the outer flange, and the inner ends of the rods are attached to a spring at the middle of the tie.

Nos. 369,755 and 369,756; date, September 13, 1887; William L. Van Harlingen, sr.—A box cross-tie made of an inverted trough fastened to a base plate; inclined and closed ends. It incloses a wooden tie or wooden bearing blocks. The rail is fastened by wood-screws with wide heads. Also a metal tie with end boxes to contain springs on which the rails rest.

No. 370,072; date, September 20, 1887; R. C. Lukens.—A cross-tie of T section, with slots in the web for attaching weights or anchors to keep the track in position. The rails are fastened by lugs and bolts.

No. 370,192; date, September 20, 1887; D. C. Heller.—A hollow box-tie of rectangular section, with the top cut away under the rails. The tie is filled with concrete and has two wooden blocks to which the rails are spiked.

No. 370,226; date, September 20, 1887; C. W. Yost.—A flat tie with lugs, and a separate bed-plate, with lugs, for each rail.

No. 370,634; date, September 27, 1887; J. Mahoney and D. W. Shockley.—A cross-tie of ⊥⊥ section, with a saddle plate for each rail seat. The plate has a lug for one flange and a clip is bolted on the other. See No. 280,200.

No. 371,110; date, October 4, 1887; W. H. Troxell.—A cross-tie with raised rail seat and outer lugs. Hooked bolts, with nuts on the outer side of the chair, hold the inner flange of the rail.

No. 371,780; October 18, 1887; J. Moser and E. Moeckel.—A cross-tie of T section, with a chair at each end; each chair has an inclined rail-brace and two hook-bolts.

No. 372,230; date, October 25, 1887; A. McKenney.—Cross-ties of channel ⊓ section, with one end cut off at an angle to allow of a diagonal tie to the next transverse tie, each set of three ties making a letter N on plan. Arranged continuously.

No. 372,525; November 1, 1887; J. A. Dunning.—A hollow rectangular cross-tie, with open inclined ends; bottom and sides have corrugations, transverely and vertically. Bolted clip fastenings.

No. 372,703; date, November 8, 1887; I. A. Perry.—A cross-tie made of two old rails, with saddle chairs fitting over the heads of these rails. Track rails fastened by chair and sliding wedge, being held by flange and web.

No. 372,864; date, November 8, 1887; C. Netter.—A cross-tie of T section, with the ends beyond the rails bent down vertically and then horizontally. Rails fastened by bolts having hooks, which take hold of the bottom of the web of the tie.

No. 372,879; date, November 8, 1887; J. H. Stull.—A cross-tie made of a plate bent to a semi-circular form ◡, and semi-cylindrical at the ends ⊂⊃. Rails fastened by clamps. Open ends.

No. 373, 656; date, November 22, 1887; W. P. Hall and C. C. Barnett.—A cross-tie of semi-circular section ⌒, with open ends. Shoulders pressed out to prevent spreading. Rails fastened to saddles or straps. (See 375,996.)

No. 375,005; date, December 20, 1887; R. S. Sea.—A cross-tie of channel section, with closed ends. A strengthening plate is bolted to the under side of the top table, and the side flanges are deeply notched to give elasticity. A metal block is bolted under each rail, and the rails are secured by bolted plates.

No. 375,856; date, January 3, 1888; R. T. White.—A cross-tie of ⊥ section, with high chair at each end to receive the web of a girder rail. Intended for street railways. (See 385,395.)

No. 375,996; date, January 3, 1888; W. P. Hall.—A hollow cross-tie, made of a plate bent almost cylindrical, but with the bottom open and flat on top. The rails are fastened to saddle straps. (See 373,656.)

No. 376,214; date, January 10, 1888; J. W. Smith.—A hollow rectangular cross-tie, with holes in the top to admit the rail chairs, which rest on coiled springs inside the tie.

No. 376,884; date, January 24, 1888; William B. Henning.—A flat bar, bent up at the ends to embrace the flange and web of rail. Loose angle clamps on inside of rail. (See 323,809.)

No. 377,162; date, January 31, 1888; G. Kelton.—A cross-tie of channel section ┌─┐, with a separate bottom, having projections on its inner side to give a hold to the pulp with which the tie is to be filled. The rails are fastened by hooked bolts, with nuts inside the tie, cavities being left in the pulp filling.

No. 378,280; date, February 21, 1888; F. L. Barrows.—A cross-tie of inverted trough section, with clips struck up on the outside of the rail to hold its flange, and clips lengthwise on the inside of the rail to hold a rail fastening.

No. 378,930; date, March 6, 1888; J. Hill.—A flat cross-tie, corrugated lengthwise top and bottom. The rail is keyed to a chair. The inventor proposes to use a double-headed rail.

No. 379,312; date, March 13, 1888; S. B. Jerome.—A hollow rectangular cross-tie, made of a bent plate. It is to be filled with straw, sawdust, etc., and has a narrow bearing-block along the underside of the top, to which the rails are spiked. The ends are closed by wood or cement blocks.

No. 379,399; date, March 13, 1888; J. Jacobs.—A cross-tie of channel section └─┘ with closed ends; a top plate is bolted on by side clamps to form a rail seat. The tie is to be filled with concrete, etc.

No. 379,574; date, March 20, 1888; C. P. Hawley.—A cross-tie of I section, with the top flange bent to make a rail brace. A longitudinal bridge is used under the rail at joints.

No. 379,576; date, March 20, 1888; C. P. Hawley.—A cross-tie of ⊥ section, with slots for the web of a T girder, forming a rail seat, or which can be made a longitudinal bearing.

No. 380,623; date, April 3, 1888; H. L. De Zeng.—Improvements upon Nos. 334,696 and 348,550.

No. 381,125; date, April 17, 1888; F. X. Georget.—Improvements upon No. 365,511.

No. 381,860; date, April 24, 1888; E. R. Stiles.—A cross-tie of channel section └─┘, with a wooden block under each rail.

No. 382,134; date, May 8, 1888; W. H. Britton.—A cross-tie of T section, with the vertical web corrugated vertically. The rails are secured by lugs and clamps.

No. 382,394; date, May 1, 1888; J. B. Sutherland.—A cross tie of approximately Y section; curved like the section of a yacht, and with the top edges bent in to form horizontal flanges for the rail chairs.

No. 382,855; date, May 15, 1888; F. Barhydt.—A hollow box cross-tie, with closed ends. There is a wooden block the full size of the face of the tie at the top, and another at the bottom; both inside. Coil springs are interposed between the top and bottom sections.

No. 383,118; date, May 22, 1888; M. Fitzgerald.—A cross-tie of channel section ┌─┐, with solid ends. Fixed lugs and hooked spikes are the rail fastenings.

No. 384,785; date, June 19, 1888; Jacob Reese.—A cross-tie of ∩ section, with a groove along its top table; rail seat bolted on top. The rail is secured by a bolt passing under it and through the chair, having Γ washers to hold the rail flange. It is to be rolled from a plate of No. 7 steel 24 inches wide; bedded in ballast.

No. 385,395; date, July 3, 1888; R. T. White.—A channel cross-tie of U section, with rails secured to saddles by bolts and clips. (See 375,856 and 386,420.)

No. 385,492; date, July 3, 1888; D. Y. Wilson.—A cross-tie made of two angles ┘ └, with a base plate and channel plate for rail seat at each end. Rails bolted through top and bottom plates.

No. 386,119; date, July 17, 1883; R. W. Flower, jr., and S. L. Wiegand.—A hollow cross-tie of rectangular section, with part of the bottom cut away and turned down to prevent lateral movement. The rails are spiked to wood blocks inside the tie.

No. 386,156; date, July 17, 1888; J. A. Ogden.—A cross-tie of channel section ⊔, wide at the bottom, with bearing blocks and hook-fastenings for the rails.

Nos. 386,356 and 386,357; date, July 17, 1888; H. Shultzen.—A channel tie ⊔, with the middle part of the bottom cut away and turned up to prevent lateral movement. The rail is fastened to a wooden block by **Z**-clips and a longitudinal bolt under the rail, or by diagonal bolts. (Now being manufactured by the Standard Steel Tie Company, of New York.) (See Appendix B of the report on metal track.)

No. 386,389; date, July 17, 1888; A. Durand.—A cross-tie of inverted trough section, with clips and channels stamped in it. (See description on p. 25.)

No. 386,420; date, July 17, 1888; R. T. White.—Hollow box cross-ties of different sections, made of bent plates. Cross-section intended to give elasticity. (See 385,395.)

No. 388,277; date, August 21, 1888; A. J. Hartford.—A flat cross-tie, with end turned up, and a bent plate tie bridge, arched in the middle, bent to form a shoulder for inner flange of rail; the rail rests on this plate and the end is turned over the outer flange and secured by a bolt through both plates.

No. 389,464; date, September 11, 1888; L. Haas.—A cross-tie of rectangular section; top cut away at ends and middle. Wooden block under each rail. (See 391,704.)

No. 390,014; date, September 25, 1888; R. P. Faddis.—Wooden stringers, with flat iron tie plates across top and under rail, with **U** bolts embracing the stringers. For street and steam railways.

No. 390,370; date, October 2, 1888; I. G. Howell.—A cross-tie of channel section ⊓, with blocks under the rails. The top is cut away for the rail, and the rail clamps are fastened by hooks.

No. 391,492; date, October 23, 1888; W. J. Stifler.—A flat cross-tie with diagonal grooves on the under side near the ends to receive the heads of the bolts of the two plates, each with a lug, which form one rail seat.

No. 391,704; date, October 23, 1888; L. Haas.—A cross-tie of channel section ⊔, higher at the rail seats, with notched flanges for the rails. (See 257,752.)

No. 391,909; date, October 30, 1888; A. H. Ames.—A flat cross-tie, with flaring ends of channel section ⊓, having riveted and bolted clips for rail fastenings.

No. 392,849; November 13, 1888; J. Cabry and W. H. Kinch (of England).—A rolled steel cross-tie of inverted trough section, with lugs stamped out. Rails secured by keys driven between flange and lug. (In use on the Northeastern Railway, in England.)

No. 393,515; date, November 27, 1888; D. M. McRae.—A wooden or iron tie, with metal sockets at ends forming rail seats.

No. 394,738; date, December 18, 1888; G. W. Thompson.—A hollow cross-tie of rectangular section, with a metal bearing-block inside under each rail. Bolted clip rail fastenings.

No. 395,134; date, December 25, 1888; M. Hagarty.—A cross-tie made of two channels placed back to back ⊐⊏, inner lug on one, outer lug on the other. The bolt holes in vertical web are elongated to allow the channels to be shifted to let rail in.

No. 395,304; date, December 25, 1888; C. F. Yarbrough.—Hollow cross-ties of rectangular section, with open ends and openings at sides. Wood blocks may be used, or the ties may be filled with ballast.

No. 396,160; date, January 15, 1889; H. Hipkins (of England).—A stamped metal cross-tie of ⌒ section, with lugs and rib stamped out of top table. (Patented in England, 1888.)

No. 396,473; date, January 22, 1889; C. P. Espinasse (of France).—A cross-tie of ⊥ section, with vertical web cut away for rail chair to which rail is secured by wooden wedge.

No. 398,004; date, February 19, 1889; S. U. Smith.—A cross-tie of channel section ⊓, with closed ends. The rails rest on the ends of a separate cross-plate, with fixed lugs inside, and bolted plates outside.

TREATMENT OF RAILWAY TIES IN ENGLAND.

The information given below is taken from a paper on "English Railroad Track," by Mr. E. E. Russell Tratman (Transactions of the American Society of Civil Engineers, June, 1888). The matter referring to the Great Northern Railway (of Ireland) was taken by Mr. Tratman from a highly interesting paper, "Description of a Creosoting Yard for Railway Purposes," by Mr. W. Greenhill, read before the Institution of Civil Engineers of Ireland, in May, 1886; the paper contains very full particulars, in detail, of the plant and process, results of tests, cost, etc., and is especially interesting in that it describes work done by a railway company in treating timber for its own use.

The ties are usually of Baltic red wood, 10 by 5 inches by 9 feet, spaced 2 feet 9 inches to 3 feet center to center. They are almost invariably creosoted, with about 7 pounds of oil per cubic foot. Some roads have the creosoting done by contract, others have their own plant for the work. Among the latter may be mentioned the Lancashire and Yorkshire Railway and the Great Northern Railway (Ireland), both of which have very large and complete plants, and pay careful attention to the important point of tie preserving. [See also paper by Mr. John Bogart, M. Am. Soc. C. E., entitled "The Permanent Way of Railways in Great Britain and Ireland; with Special Reference to the Use of Timber Preserved and Unpreserved," and read November 20, 1878.*] I do not think enough practical attention is paid in this country to the question of preserving railroad ties, and some points in the matter may be learned from English practice.

Usually the ties are of rectangular section, but on the Midland Great Western Railway (Ireland), they are preferred of half-round section, except where the bearing-plates (bed-plates) are used. Mr. Price says that for heavy traffic he would prefer sleepers 11 by 5½ inches; he uses, however, sleepers 10 by 5 inches, 8 feet 11 inches long, always creosoted. The following is from the company's specifications: The timber is to be of good sound Baltic redwood, free from shakes and other defects, well seasoned and dry; 90 per cent. of both rectangular and half-round sleepers to have not less than 7½ inches diameter of heart-wood, and 10 per cent. not less than 7 inches at both ends. On one side the rectangular sleepers to have 50 per cent. sharp edges down to 9 inches surface, and 50 per cent. not less than 8 inches, and on the other side all edges to be sharp. The rectangular sleepers are to be grooved and bored and the half-round sleepers to be grooved, in accordance with the templates which will be supplied by the engineer. After being grooved and bored they are to be placed in a receiver and thoroughly impregnated with the best creosote oil (an equal mixture of light brown and black oil) under such pressure and for such time as shall entirely fill the pores with the liquid. The sleepers are not to be creosoted till they have been stacked in the contractor's premises for at least three months after inspection by the engineer.

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* Transactions, Vol. VIII, page 17, January, 1879.

The engineer will reject, either before or after delivery, any sleepers which do not comply with the above conditions, or any sleepers the sap-wood of which has not been fully creosoted.

(1) LANCASHIRE AND YORKSHIRE RAILWAY.

The ties, after being well seasoned, are passed through a combined adzing and boring machine, which first cuts out a seat about one-sixteenth of an inch deep for the chairs, in order to give them a uniform bearing, and then simultaneously bores the eight holes required for chair fastenings in each tie. The machine will seat and bore about one hundred ties per hour.

The ties are then placed on small iron trucks and drawn on a tramway of 3-foot gauge into the cylinder, which contains eight trucks with forty-seven ties each, or three hundred and seventy-six ties in all. The cylinder is 77 feet long, 6 feet internal diameter, built of one-half-inch wrought-iron plates and having egg-shaped ends. When the full number of ties has been put in, the doors or covers are put on and hermetically fastened by means of dog-bolts and screws, and the air exhausted by a steam ejector. The creosote is then introduced, heated to a temperature of from 100 to 120 degrees Fahrenheit; the air-pump then ceases to work and the pressure pump is put into operation, the full pressure of 150 pounds per square inch being obtained in about ten minutes; this pressure is maintained for about fifty minutes and is then withdrawn. The spare creosote is allowed to run back into the reservoir under the cylinder, the cover is removed, and after the ties have been left to drip for about fifty minutes, they are taken out of the cylinder. About 3 gallons of creosote are allowed for each tie, or 9¼ pounds per cubic foot of timber. The efficiency of the process is ascertained by weighing three or four ties out of every charge, both before and after the operation, the additional weight showing the quantity absorbed, which averages about 30 pounds per tie:

	Pounds.
Average weight of tie before creosoting	128
Gain in weight during process	30
Average weight of creosoted tie	158

The whole operation for one charge of ties occupies about one hundred and thirty-two minutes, as follows, but varies slightly, however, according to the moisture in the timber:

	Minutes.
Ejection vacuum	13
Pumping commenced and tank filled	9
Full pressure obtained in	10
Full pressure maintained for	50
Spare creosote allowed to drip from ties	50
Total	132

From the creosoting cylinder the timbers are run back into the chairing shed, where the chairs are attached to the ties by a machine (somewhat on the style of a steam hammer) which, at one stroke, drives the four fastenings for each chair. This machine will "chair" about seventy ties per hour.

The time occupied in seating, boring, creosoting, and chairing three hundred and seventy-six ties is as follows:

	Hrs.	Min.
Stating and boring	3	40
Running trucks into cylinder	0	20
Creosoting	2	12
Withdrawing charge from cylinder	0	20
Chairing	5	14
Total	11	46

or 1 minute and 53 seconds per tie.

The cost of the operations, not including the value of the machines, is as follows:

Loading white ties	per 100	$0.36
Adzing and boring	do	.62
Tanking,	do	.64
Creosote, 300 gallons	do	6.75
Chairing and spiking	do	2.44
Total		10.81

or 10.81 cents per tie.

The whole of the work is done at the company's store yards at Castleton and Knottingley, and is let piece-work at the above rates.

(2) GREAT NORTHERN RAILWAY (IRELAND).

In 1876, when a number of railways were amalgamated to form this system, the new company decided that all the ties should be creosoted, and that to insure the work being efficiently performed, it would erect a suitable plant of its own for sawing, grooving, and creosoting the timber to be used for ties. After being sawed, the ties are taken to the grooving-machine, which forms a groove or seat for the base of flange rails by means of cutters making 2,000 revolutions per minute. Boring machinery, with twisted augers, was used for a short time, but the adoption of the improved ragged spike, which cuts its own way without splitting the tie, enables holes to be entirely dispensed with, and insures a tighter fit of the spike. After being grooved the ties are run out into the yard on a tramway of 30-inch gauge, and stacked to a height of 14 feet, alternate tiers on edge and on flat.

The cylinder is 60 feet long (6 tie lengths), 6 feet diameter, built of three-eighths-inch plates. The safety valve is set at 110 pounds, but seldom rises; it is, however, sometimes lifted to release air and water when the pressure pumps are working. There are six tanks, of such a size that a vertical inch of the six tanks represents 156 gallons; a float is connected with a gauge and scales, which show the gallons or pounds of creosote forced into the cylinder. There are 1½-inch pipes in the cylinder, through which the steam is forced to heat the creosote to 120 degrees Fahrenheit, thus dissolving the naphthaline, etc., and rendering the creosote quite fluid. There is an air-pump, 6¼ by 10 inches, which exhausts the air from the cylinder, and the creosote enters by the atmospheric pressure on the tanks; the partial vacuum does not extract the sap or affect the timber. When the cylinder is nearly full the valve is closed, air-pump stopped, and the two force pumps, 3 by 4 inches, put to work. Three hours of steady pressure are required. The consumption of oil varies from 140 to 180 casks of 36 to 38 gallons each, per week, and the quantity used annually is about 250,000 gallons. The average quantity of creosote injected is 2.35 to 2.57 gallons, or 25 to 27 pounds per tie. About nine months' seasoning is customary, but a longer period is considered desirable so as to insure dryness.

"Little or no creosote can be forced into a thoroughly wet sleeper, even at high pressures, and a thoroughly dry sleeper will readily absorb a large quantity of oil which, when solidified by exposure to the air, no moisture, either from air or wet ground, will succeed in removing."

CIRCULAR IN REGARD TO CHESTNUT-OAK TIES.

FOR INFORMATION OF RAILROAD MANAGERS.

U. S. DEPARTMENT OF AGRICULTURE, FORESTRY DIVISION,
Washington, D. C., December, 1887.

GENTLEMEN: Hoping that you have appreciated the manner in which the Forestry Division of this Department has, by its first Bulletin, attempted to call the attention of railroad managers to the need of economy in the use of forest supplies, allow me, in furtherance of such economy, to present the following statements, which may be of interest to you.

In the use of oak for cross-ties, the specifications of most roads, especially those of the South, call for white oak (*Quercus alba*), a timber which is sought for also by almost every industry employing oak, and which is therefore rapidly decreasing and approaching comparative exhaustion. Meanwhile, millions of feet of tan-bark or chestnut oak (*Quercus prinus*) are rotting in the forests, after being stripped of their bark, because their value for cross-ties is not known or is underestimated in many regions.

This lack of appreciation of the value of this wood causes not only waste of the wood itself, but waste of the bark also, as without ready demand for the wood it does not pay to peel the larger limbs.

From information furnished by Dr. Mohr, of Mobile, Ala., an expert in forestry statistics and agent of this Department, it appears that from the line of the Louisville and Nashville Railroad, south of the Tennessee River, between 5,000 and 7,000 cords of bark are shipped annually, involving the felling in that district alone of from 10,000 to 13,000 trees which are consigned to useless destruction, while capable of yielding not less than 100,000 first-class railroad ties.

As to the lasting quality of the timber of chestnut oak, experiences are reported from Cullman, Ala., to the effect that posts of this oak outlast those made of white oak, partly, probably, because the timber is peeled. One reliable report states that tan-bark-oak posts were found to be sound after twelve years, while those of white oak in the same construction had to be replaced several years sooner. Reports from railroad companies where this wood is used for ties give their life as from five to ten years, while the reports for white oak give from three to twelve years. In the average, all the oaks which are known as "white oaks," named below, last between seven and eight years in the road-bed.

That the oaks of this class may be used for railroad construction interchangeably, and do not offer any appreciable differences in the qualities most essential for a good railroad tie, the following table, compiled from the Census Report, may serve to show. The column of specific gravity will allow an estimate in regard to adhesion of spikes, while the column of indentation allows an estimate as to resistance to cutting of rail.

The position as to quality, in comparison with the other kinds mentioned, is indicated by numbers in parentheses.

Description.	Range.	Weight per cubic foot.	Specific gravity.	Resistance to indentation.	Elasticity.	Transverse strength.
White oak (*Quercus alba, L*.).	East of the Rocky Mountains.	46.35	0.7470 (4)	3388 (6)	97089 (2)	905 (4)
Chestnut or rock-chestnut oak (*Quercus prinus, L.*).	Northeastern and in Kentucky, Tennessee, and Alabama.	46.73	0.7499 (3)	3688 (5)	125473 (1)	1031 (2)
Basket or cow oak (*Quercus Michauxii, Nutt.*).	Southeastern	50.10	0.8039 (2)	3725 (4)	96373 (3)	1118 (1)
Burr, mossy-cup, or over-cup oak (*Quercus macrocarpa, Michx.*).	Northern United States.	46.45	0.7453 (6)	3730 (3)	92929 (4)	982 (3)
Post or iron oak (*Quercus obtusiloba, Michx.*).	East of Rocky Mountains.	52.14	0.8367 (1)	4415 (1)	83257 (5)	872 (6)
California white oak (*Quercus Garryana, Dougl.*).	Pacific Coast	46.45	0.7453 (5)	3846 (2)	81109 (6)	879 (5)

From these figures it would seem that, contrary to the accepted notion, the white oak, par excellence, is inferior in all particulars to the chestnut oak, and in general not superior to any of the others.

Trusting that the above information will be of value to you, and that, so far as your conditions enable you to make use of it, you will do so, and thus to some extent aid in economizing timber supplies.

Yours, respectfully,

NORMAN J. COLMAN,
Commissioner of Agriculture.

NOTE.—The objection to the injurious influence on their durability of cutting trees in the sap, which is done to obtain bark, is met by leaving the trees full length, with limbs and leaves untrimmed for a fortnight, when by the action of the leaves a more thorough seasoning will be accomplished than can otherwise be obtained.

This practice is common abroad wherever summer felling is a necessity, and has proved itself so satisfactory that preference is given to cutting timber in the leaf.

CORRESPONDENCE IN REPLY TO THE CIRCULAR ON CHESTNUT-OAK TIES.

Louisville, New Orleans and Texas Railway Company.—My own experience confirms fully the facts stated in your circular. (James M. Edwards, vice-president and general manager.)

Richmond and Allegheny Railroad.—I have ranked chestnut oak with white and post oak for thirty years past, and in the middle sections of the State the impression is that, cut under similar conditions, it rather outlasts the white oak. (R. D. Whitcomb, chief engineer.)

Cincinnati, New Orleans and Texas Pacific Railway Company.—I have seen your circular concerning the value of chestnut oak, and am glad that you called attention to the subject.

We have had its use specified for our cross-ties on the Cincinnati Southern Railway since the first construction of the track, in 1876. (G. B. Nicholson, chief engineer.)

Nashville, Chattanooga and Saint Louis Railway.—Please accept my thanks for your circular letter with reference to chestnut oak for cross-ties. Our chief engineer advises me that he classes it third best for this purpose, and considers it but little inferior to white oak for cross-ties. (J. W. Thomas, president.)

Saint Louis and San Francisco Railway Company.—Ninety-five per cent. of the timber fit for ties on our lines is composed of white, burr, or post oak. We have occasionally obtained a few ties made of what is called chinquapin oak, which is a variety of chestnut oak, and has long been recognized to be one of the best varieties of timber for cross-ties. (James Dun, chief engineer.)

Philadelphia, Wilmington and Baltimore Railroad Company.—We have bought several thousand of *Quercus prinus* in the Virginia counties bordering on the Chesapeake Bay this last season. I consider it every way equal, if not superior, to the *Quercus alba* ties. If you can direct me where the bark of the *Prinus* is being used, I will at once send our agent to see what we can do towards getting the cross-tie in the spring after the trees are barked. (J. N. Mills, superintendent.)

Mexican Central Railway Company.—We are using on our railroad now, so far as we draw from the United States, for the main line, cedar grown in northern Michigan and southern Canada, and we have already contracted for 1,000,000 ties for next year's supply.

We have also bought 25,000 white-oak ties. These are the only oak ties that have been purchased in the three and a half years of my presidency, with the exception of some small lots of bridge ties. So, as you see, we have not been very great sinners in the matter of the use of white oak.

The 25,000 oak ties were for use in curves; heretofore we have used on curves mesquite ties grown in Mexico; the supply was never plentiful, and it had materially diminished.

The information you give us, therefore, may become of great importance. (Levi C. Wade, president.)

SPECIFICATIONS FOR WOODEN CROSS-TIES.

PROPOSED GENERAL SPECIFICATIONS FOR CROSS-TIES.

TIMBER.

Cross-ties will be accepted of the following varieties of timber: Oaks of the various kinds known as "white," "black," "yellow," "rock," or "chestnut," "burr," and "post," red oak, black locust, second-growth white chestnut, beech, red elm, cherry, maple, butternut, tamarack, and yellow pine of the long-leaved Southern hard pine variety cut from untapped trees, white and red cedar. Hemlock may be accepted but only under special contracts.

SIZE.

First class. Eight and one-half feet in length, 7 inches in thickness, and not less than 7 inches width of face on both sides at the small end.

Second class. Eight feet in length, 6 inches in thickness, and not less than 7 inches width of face on both sides at the small end; and in each class there must be at east one-fourth of the whole number that will be not less than 10 inches in width of faces.

MANUFACTURE.

All ties must be made from sound, thrifty live or green timber, free from loose or rotten knots, worm-holes, dry-rot, wind-shakes, splits, or any other imperfections affecting the strength or durability of the timber.

Not more than 1 inch of "sap wood" will be allowed on the edges or corners, and none at all on either face of the ties; they must be hewed or sawed with the faces perfectly true and parallel, of the exact thickness specified; the faces must be out of "wind," smooth, and free from any inequalities of surface, deep score marks, or splinters; they must be cut or sawed square on the ends to the exact lengths given and be generally straight in all directions, and will not be accepted if more than 3 inches out of straight in any direction; and must be peeled or stripped entirely free from the bark before being delivered.

No "square ties," either hewed or sawed, will be accepted excepting under special contracts. No split ties will be accepted under any circumstances, and "culls" only at the option of the company, and at such prices as may be agreed upon from time to time.

DELIVERY.

All ties delivered along the line of the railway must be stacked up in neat square stacks of fifty ties in each, with alternate layers crossing each other, and on ground, wherever possible, as high or higher than the grade of the railroad, and in such position as to admit of being counted and inspected with ease and facility. Ties delivered at suitable and convenient places, acceptable to the company, will be inspected, and bills made for all received and accepted up to the last day of each month, and payment will be made for same on or about the —— day of the succeeding month.

—— ——,

Chief Engineer.

SPECIFICATIONS FOR CROSS-TIES USED BY NEW ORLEANS AND NORTHEASTERN RAILROAD.

The timber shall be either white, post, burr, or chestnut oak, mulberry, black locust, red cypress, or long leaf yellow pine, cut in any month of the year of delivery except February, March, April, May, or June, from young, sound, living trees. It must be free from rotten or loose knots, worm-holes, dry-rot, wind-shakes, or other imperfections affecting the strength and durability of the wood.

The cross-ties must be 9 feet long and straight in all directions, not less than 7 nor more than 7½ inches in thickness. They must have not less than 7 inches of heart face.

The hewn surfaces must be parallel, free from objectionable score-marks, and not winding. The ends must be cut square and all bark removed. No sawed ties will be accepted.

The ties must be delivered on the right of way of the railway, not lower than the grade, and not higher than 8 feet above grade.

They shall be scattered for inspection in such a manner that all parts of every tie can be seen and measured by the inspector.

All accepted ties must be arranged in piles formed of layers separated by two ties.

PROPOSAL.

The undersigned hereby propose to furnish, according to the foregoing specifications ——— cross-ties. Said cross-ties to be delivered as aforesaid at ——— ———, at the rate of —— cents per cross-tie.

The undersigned further propose to commence work within —— days from date hereof, and complete the delivery of ties on or before —— ———, 18—.

Signed this —— day of ———, 18—.

Name of firm : ——— ———,
By ——— ———,
——— ———,
——— ———.

Reference : ——— ———.
Post-office address : ——— ———.

REPORT OF EXPERIMENTS IN WOOD SEASONING.

CHEMICAL LABORATORY,
Aurora, Ill., January 9, 1889.

Mr. G. W. RHODES,
Superintendent M. P., Chicago and Burlington R. R. Co.:

DEAR SIR: Herewith is submitted a report on a second series of "experiments in the fluctuation of moisture in wood during seasoning," a report on first series having been submitted March 2, 1887. Accompanying this are diagrams showing the weekly fluctuation of the moisture for every piece used during the experiments, based upon the exact percentages of moisture in the tables given herein. In the diagrams the nearest to a whole per cent. was taken.

The object of this second series was to corroborate, if possible, the conclusions of the first series, viz: (1) To determine the time that outdoor seasoning begins and ends as indicated by the moisture; (2) to ascertain whether the wood will again take back moisture during the wet seasons of the fall and spring; (3) effects of size of wood; and (4) whether one season is sufficient to season wood.

To determine these questions, fifteen pieces of unseasoned timber, as wet as could be obtained, were placed out of doors in a latticed shed, and loosely piled with cleats between and a board topping, all to protect from direct dripping and rain, and yet to be under the same conditions as outdoor seasoned lumber.

All of the oak was from Kentucky, the pine from Michigan, ash from Arkansas, white-wood from Tennessee, and elm from Michigan.

The first lot of lumber, including all but the pine, was received Wednesday, December 29, 1886, and the first determination of moisture made Monday, January 3, 1887. The four pines were received later, the first moisture determination being made April 18, 1887. The following are the determinations and the kind of material:

Letter.	Kind.	For what used.	Cross dimensions.	Length.	
			In. *In.*	*Ft.*	*In.*
A	Oak	Draw wood	4¾ by 14	17	0
F	do	do	4½ by 8	8	2
D	do	End plate	3½ by 12½	9	3
E	do	End sill	5 by 9½	9	6
J	do	do	9 by 9½	10	0
K	do	Corner post	4 by 5	7	4
G	do	Draw beam	9¼ by 9½	12	2
I	do	Side brace	3 by 4½	7	0
B	Ash	Corner post	4 by 9	16	0
C	White-wood	Outside	3 by 12	16	0
H	Elm	Brake beam	4½ by 6½	12	0
L	Hard pine	Flooring	2 by 10	18	0
M	Soft pine	Roofing	1 by 6	16	0
N	Hard pine	Side sill	5 by 9½	30	0
O	do	Side plate	2½ by 5	30	0

There are yet running two pieces of pine (N and O), and when they are finished a third report will be made on "fluctuation of moisture in wood and miscellaneous experiments in wood seasoning."

On every Monday morning the amount of moisture was determined. Following is the method employed in the estimation: From the same end of each piece, exactly 3 inches was sawed, and from this piece on the end freshly sawed, and exactly in the center, borings of the wood were obtained, using a ⅝-inch bit. These borings or chips were transferred, as quickly as they left the bit, to a previously weighed drying tube, and when about 2½ inches had been bored, the tube is quickly and securely stopped and again weighed. The amount of chips of the wood is then known. This tube containing the chips is placed in an air-oven for one hour, at a temperature of 230 degrees Fahrenheit; then taken out, cooled and weighed. This is repeated, drying fifteen minutes each time, until the weight begins to increase (due perhaps to oxidation of the resinous matters), when the lowest weight obtained is taken as the correct one. The determinations were all made by the same person, except a few during March and April, 1888, and thus any "personal error" avoided that might arise from different persons doing the work.

COMMENTS.

Oak.—It will be noticed in the tables of percentages of moisture that determinations were made in eight pieces of oak of different dimensions, only one of which (A) was of sufficient length to last more than one year. In this piece the moisture fluctuated very much, although there is noticeable decrease commencing in April, and being the lowest the latter part of November, when it increased from 30 per cent. to 35 per cent., and then went down again until it ended in March. I do not attribute the 5 per cent. increase in December to the wood absorbing moisture, but to the fact that the per cent. of moisture in the center or heart of green oak would amount to this difference. An experiment was made on oak to determine this point, a report of which will be given in the third series. In oak G (dimension 9½ inches by 9½ inches by 12 feet 2 inches), the moisture at start in January was 43 per cent., and commenced to drop in March and April and in the following months until the end in November, fluctuating between 38 per cent. and 41 per cent. The remaining oak (K, F, I, D, J, and E) all commence to decrease in percentage of moisture during March and April, and show a continual decrease toward the end of the pieces. Unfortunately these pieces were not of sufficient length to allow the moisture to reach the lowest limit, but from them we can tell the spring months which the seasoning begins.

Pine.—Experiments with the pines were not commenced until April 18, 1887, and two test pieces (N and O) are still under observation. In these there is an almost immediate decrease in percentage of moisture. In N, the moisture dropped from 28 per cent. in April to 12 per cent. October 1, when it increased to about 16 per cent., remaining at that through the full winter and spring, and in the following May again began to decrease until 13 per cent. was reached, where it remained with slight variation. In O, the moisture in April, 1887, was 20 per cent., and by the following August, 1887, had dropped to 9 per cent., then increased to about 14 per cent., where it remains with the exception of a slight drop in the summer.

Months of 1888: The piece of roofing, 1 inch thick, had 14 per cent. of moisture in April, 1887, and which decreased to 10 per cent. by August, but the following fall and winter months it increased to 16 per cent., and did not decrease during the winter and spring months, until August, 1888, when it commenced to drop, and by June, 1888, the percentage was about the same as the summer of 1887. This piece took up moisture during the wet seasons.

The pine L (2 inches by 10 inches by 18 feet) when first commenced in April contained 18–20 per cent. moisture, but immediately began to decrease and reached the lowest percentage of moisture in the following July and August, then increased during the fall and winter, amounting to 17 per cent. during February and March of 1888, and again beginning to decrease in April and continuing to do so until the piece ended in the middle of July. The piece also took up moisture during the wet seasons.

Ash.—Only one piece of ash was used during the experiments, which contained about 22 per cent. of moisture during the months of January, February, and March, but during April the percentage began to decrease, being the lowest in August (11 per cent.) and remained at about 12 per cent. during the following fall and winter months, and until March, 1888, when the piece ended.

Elm.—The one piece of elm, H, showed a steady decrease of moisture from 29 per cent. in January, 1887, to 16 per cent. in November of the same year, when the end of the piece was reached.

White-wood.—This wood, C, had 16 per cent. of moisture in January, 1887, and began to decrease in April, reaching the lowest (10 per cent.) in July and August, and varied but 1 or 2 per cent. during the remainder of the period of observation, which ended the middle of November of the same year.

Percentages of moisture.

Date.	Oak.	Ash.	White wood.	Oak.				Elm.	Oak.			Pine.			
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.
1887.															
Jan. 3	33.06	19.79	16.21	46.56	44.23	38.75	43.21	28.51	47.23	37.75	42.90	......	......	......	.....
10	36.53	22.31	14.80	46.09	45 07	40.00	42.94	28.21	44.33	37.98	43 00	......	......	......	.....
17	38.72	22.35	15.78	46.83	45.60	40.37	42.22	28.59	44.67	38.74	43.07	......	......	......	.....
24	40.73	22.42	15.52	46.25	45.41	40.28	42.68	27.83	41.63	37.77	43.26	......	......	......	.....
31	40.56	22.60	14.31	43.33	43.90	40.08	44.32	27.12	43.80	38.99	42.17	......	......	......	.....
Feb. 7	41.85	22.44	15.11	45.57	43.90	39.18	43.51	27.35	44.50	35.99	42.17	......	......	......	.....
14	42.99	22.37	15.72	46.47	43.79	41.03	42 92	28.03	44.69	37.89	42.66	......	......	......	.....
21	43.13	22.59	15.89	46.38	42.92	39.29	42.30	27.51	43.93	37.93	42.18	......	......	......	.....
28	43.78	22.49	15.03	46.20	43.31	39.48	42.80	27.39	44.59	38.85	42.69	......	......	......	.....
Mar. 7	42.11	21.67	15.45	43.64	42.88	38.47	42.10	26.85	42.70	39.00	41.36	......	......	......	.....
14	42.81	20.84	15.33	43.04	43.19	38.20	40.29	25.57	42.31	37.23	40.65	......	......	......	.....
21	42.63	21.02	15.32	45.11	43.82	38.44	40.28	24.46	42.61	37.56	43.83	......	......	......	.....
28	43.14	21.24	15.54	46.62	44.08	37 82	40.97	24 42	42.85	35.87	40.31	......	......	......	.....
Apr. 4	43.61	21.26	15.21	44.57	43.88	37.37	40.05	24.28	41.65	35.74	40.48	......	......	......	.....
11	42.85	23.26	13.98	45.56	42.26	38.50	39.62	23.60	40.76	37.09	40.22	......	......	......	.....
18	41.83	19.08	13.36	43.77	42.27	38.64	39.62	23.47	40.57	36.03	40.18	17.58	13 58	23.37	21.21
24	43.02	20.61	14.06	40.53	41.57	39.37	40.30	23.14	41.49	38.15	40.52	19.56	14.11	29.18	21.27
May 2	40.08	18.76	12.26	40.03	41.85	38.04	38.81	22.67	39 87	36.55	39.62	17.09	12.52	28.61	18.34
9	40.65	18.32	12.01	40.43	41.84	38.40	38.38	22.91	40.97	38.19	39.55	15.47	12.42	28.32	16.32
16	39.80	17.31	11.51	39.59	42.11	38.21	39.45	22.34	39.9[illegible]	38.72	39.41	13.56	11.22	26.27	14.11
23	39.95	16.88	11.10	40.68	41.34	36.82	38.34	21.69	38.94	38.42	39.51	12.69	12.64	22.77	14.22
30	39.52	16.42	11.78	41.45	41.81	37.24	37.61	22.12	39.06	37.67	39.19	13.88	8.99	27.42	14.32
June 6	45.44	16.84	12.47	42.62	41.31	37.38	38.70	21.58	38.44	36.95	38.93	15.21	14.25	25.19	15.15
13	35.96	15.87	12.19	40 97	41.01	37.71	38.94	21.23	36.63	36.11	38.22	14.65	12.17	24.24	13.29
20	39.39	14.30	11.19	40.50	40.15	37.06	36.66	20.50	34.71	34.20	38.16	13.29	11.71	19.00	10.06
27	40.10	13.91	10.40	40.49	40.41	37.28	35.39	20.16	33.11	33.63	37.07	12.72	11.36	19.82	10.52
July 4	39.78	13.31	11.34	35.51	41.12	36.56	39.03	20.20	32.56	34.65	35.57	12.79	12.54	19.05	11.25
11	40.67	13.21	11.05	34.70	41.72	35.52	38.60	19.48	31.28	36.56	32.32	12.48	12.70	20.80	9.61
18	37.76	12.61	10.46	32.47	41.22	35.89	40.65	19.23	24.43	34.76	24.57 End.	11.50	10.31 (*)	16.67	9.43
25	41.40	13.00	10.95	34.19	41.68	34.93	40.06	18.94	29.48	34.83	......	12.43	10.82	21.28	9.98
Aug. 1	40.81	11.32	9.26	31.57	39.66	31.46	39.21	17.64	21.98	35.13	......	10.89	9.70	19.47	8.64
7	37.81	13.15	9.81	33.42	39.67	21.17 End.	40.31	18.50	21.98 End.	37.72	......	11.01	9.88	19.59	8.82
15	39.15	12.69	10.55	30.56	39.68	......	40.58	17.92	......	36.80	......	11.92	11.63	17.73	10.55
22	40.49	12.36	11.56	20.50	38 92	......	40.44	17.31	......	36.09	......	12.60	11.12	15.83	10.58
29	38.43	12.45	11.22	25.66	36.38	......	41.29	17.65	......	37.32	......	13.02	11.86	16.65	10.89
Sept. 5	38.65	11.37	10.73	23.77 End.	36.88	......	40.52	16.93	......	36.94	......	12.03	11.10	15.84	10.40
12	37.37	12.23	10.80	......	34.70 End.	......	40.67	16.38	......	35.96	......	12.62	11.83	14.79	10.92
19	34.94	11.18	10.35	......	......	......	38.68	16.25	......	30.60	......	11.90	11.10	13.44	10.16
26	36.11	12.43	11.11	......	......	......	40.02	16.61	......	26.00 End.	......	12.90	12.01	14.18	11.29
Oct. 3	36.37	12.69	12.84	......	......	......	40.42	16.53	......	......	......	13.86	16.26	12.25	13.38
10	35.51	12.43	12.44	......	......	......	40.86	16.12	......	......	......	14.01	15.43	15.04	12.98
17	35.66	12.10	11.81	......	......	......	39.34	16.75	......	......	......	16.62	13.72	14.34	12.07
24	34.32	12.25	11.93	......	......	......	38.46	16.26	......	......	......	13.14	13.94	14.91	12.95
31	34.07	12.34	11.81	......	......	......	38.58	16.36	......	......	......	13.29	13.26	14.60	13.01
Nov. 7	32.77	12.04	11.29	......	......	......	35.09	16.25	......	......	......	12.70	12.54	13.73	15.03
14	32.28	11.95	11.50	......	......	......	36.68	15.15	......	......	......	12.99	12.43	14.78	12 64
21	33.44	12.23	8.39 End.	......	......	......	37.11	15.58	......	......	......	14.48	13.12	14.93	9.39
28	30.26	16.68	......	......	......	......	32.36 End.	12.70 End.	......	......	......	13.23	13.59	14.94	13.79
Dec. 5	31.43	12.70	......	......	......	......	......	......	......	......	......	13.09	13.77	14.88	13 58
12	33.03	13.03	......	......	......	......	......	......	......	......	......	14.00	14.73	15.12	14 07
19	33.60	12.80	......	......	......	......	......	......	......	......	......	13.64	14.78	14.78	13.57
26	34.46	12.80	......	......	......	......	......	......	......	......	......	13.99	14.26	14.47	13.48
1888.															
Jan. 1	34.21	13.09	......	......	......	......	......	......	......	......	......	14.46	14.53	13.30	14.00
9	34.81	13.56	......	......	......	......	......	......	......	......	......	14.97	16.10	15.56	14.78
16	34.82	13.71	......	......	......	......	......	......	......	......	......	15.11	16.32	15.38	14.59
23	34.22	13.23	......	......	......	......	......	......	......	......	......	15.43	15.81	15.39	14.25
30	33.58	12.69	......	......	......	......	......	......	......	......	......	15.42	16.31	15.79	14.17

Percentages of moisture—Continued.

Date.	Oak.	Ash.	White wood.	Oak.				Elm.	Oak.			Pine.			
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.
1888. Feb. 5	33 30	12.97	......	......	......	......	......	......	......	......	......	16.20	16.35	13.72	14.04
13	32.65	13.20	......	......	......	......	......	......	......	......	......	16.61	16.48	16.26	14.25
20	32.01	13.20	......	......	......	......	......	......	......	......	......	15.95	11.48	13.58	13 98
27	30.66	12.85	......	......	......	......	......	......	......	......	......	16.17	15.78	15.89	14.16
Mar. 5	30.08	12.57 End.	......	......	......	......	......	......	......	......	......	16.65	15.19	16.14	14.08
12	28.69	......	......	......	......	......	......	......	......	......	......	16.47	14.65	15.79	13.89
19	22.32 End.	......	......	......	......	......	......	......	......	......	......	16.01	15.80	15.41	13.43
26	......	......	......	......	......	......	......	......	......	......	......	16.13	15.22	15.61	13.79
Apr. 2	......	......	......	......	......	......	......	......	......	......	......	......	15.03	16.18	15.26
9	......	......	...	......	......	......	......	......	......	......	......	15.85	13.51	15.29	12.80
16	......	......	......	......	......	......	......	......	......	......	......	15.84	13.38	14.95	12.62
23	......	......	......	......	......	......	......	......	......	......	......	16.00	13.50	15.54	12.95
30	......	......	......	......	......	......	......	......	......	....	......	14.19	11.00	15.22	14.07
May 7	......	......	......	......	......	......	......	......	......	......	......	15.04	11.80	15.79	13.47
14	......	......	......	......	......	......	......	......	......	......	......	15.07	12.27	15.95	12.72
21	......	......	......	......	......	......	......	......	......	......	......	14.64	11.71	15.90	12 82
28	......	......	......	......	......	......	......	......	......	......	......	13.99	12.18	15.49	12.53
June 4	......	......	......	......	......	......	......	......	......	......	......	13.81	11.46	14.23	12.14
11	......	....	......	......	......	......	......	......	......	......	......	13.86	11.36	14.29	12.29
18	......	......	......	......	......	......	......	......	......	......	......	12.97	10.30 End.	13.39	11.38
25	......	......	......	......	......	......	......	......	......	......	......	14.42	......	13.14	11.25
July 2	......	......	......	......	......	......	......	......	......	......	......	12.63	......	13.16	11.44
9	......	......	......	......	......	......	......	......	......	......	......	12.95	......	13.98	12.32
16	......	......	......	......	......	......	......	......	......	......	......	12.73	......	12.71	11.87
23	......	......	......	......	......	......	......	......	......	......	......	11.93	......	12.30	11.46
30	......	......	......	......	......	......	......	......	......	......	......	12.11	......	12.56	11.92
Aug. 6	......	......	......	......	......	......	......	......	......	......	......	12.21	......	12.32	11.57
13	......	......	......	......	......	......	......	......	......	......	......	11.24	......	13.25	11.52
20	......	......	......	......	......	......	......	......	......	......	......	11.68 End.	......	12.67	11.54
27	......	......	......	......	......	......	......	......	......	......	......	......	......	12.90	11.91
Sept. 3	......	......	......	......	......	......	......	......	......	....	......	......	......	11.79	10.84
10	......	......	......	......	......	......	......	......	......	......	......	......	......	11.34	10.84
17	......	......	......	......	......	......	......	......	......	......	......	......	......	12.63	11.16
24	......	......	......	......	......	......	......	......	......	......	......	......	......	12.70	12.60
Oct. 1	......	......	......	......	......	......	......	......	......	......	......	......	......	11.87	12.04
8	......	......	......	......	......	......	......	......	......	......	......	......	......	12.69	12.70
15	......	......	......	......	......	......	......	......	......	......	......	......	......	12.53	11.89

NOTE.—In the "starred" percentage on y. pine "M," the cut was made 1 foot from previous one on account of knot. Pieces "N" and "O" have 10 feet yet to be cut. The diagrams were made on percentages up to October 29, 1888.

CONCLUSION.

Out door seasoning depends a great deal on the character of the weather during the year, that is, as to an early or late spring or fall, hot or cold summer months, or severe winter, etc., but during the experiments it may be considered to have been average Illinois weather.

The result of this series of experiments shows that the month during which the seasoning begins varies with the kind of wood.

(1) That for oak the seasoning commences in March or April; with pine the exact month can not be decided, as they were not placed under observation until late (April), but all test pieces showed a loss of moisture within a fortnight after being exposed.

Ash and white-wood commenced to lose moisture in April, and elm immediately on being exposed in January.

No law can be deduced from the experiments as to the exact time that seasoning ends, as the woods all vary, but as a general rule it may be stated that in all woods (except perhaps elm) seasoning virtually ends with the end of the summer months.

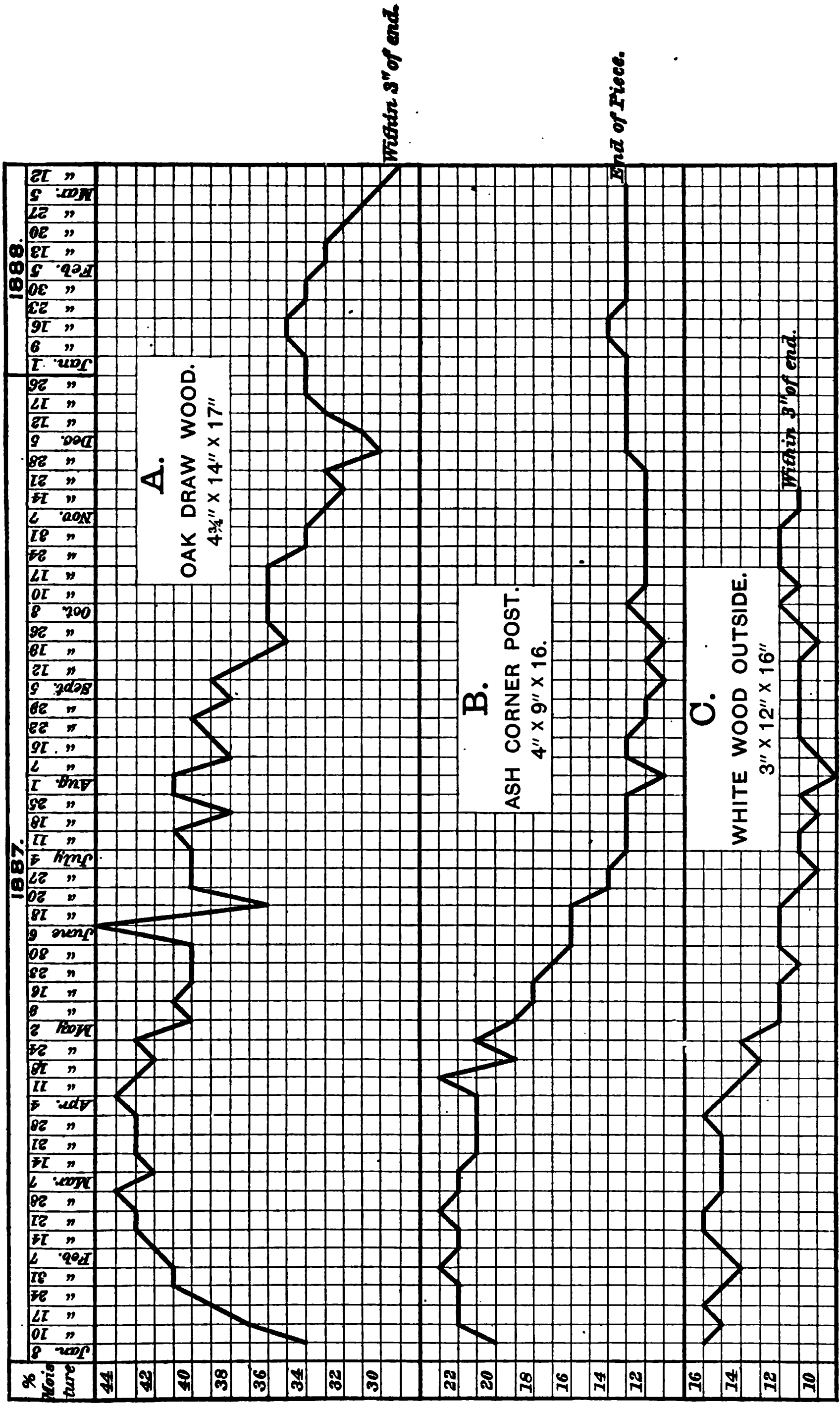
(2) All woods take up moisture in slight amounts during wet weather of the fall and winter months.

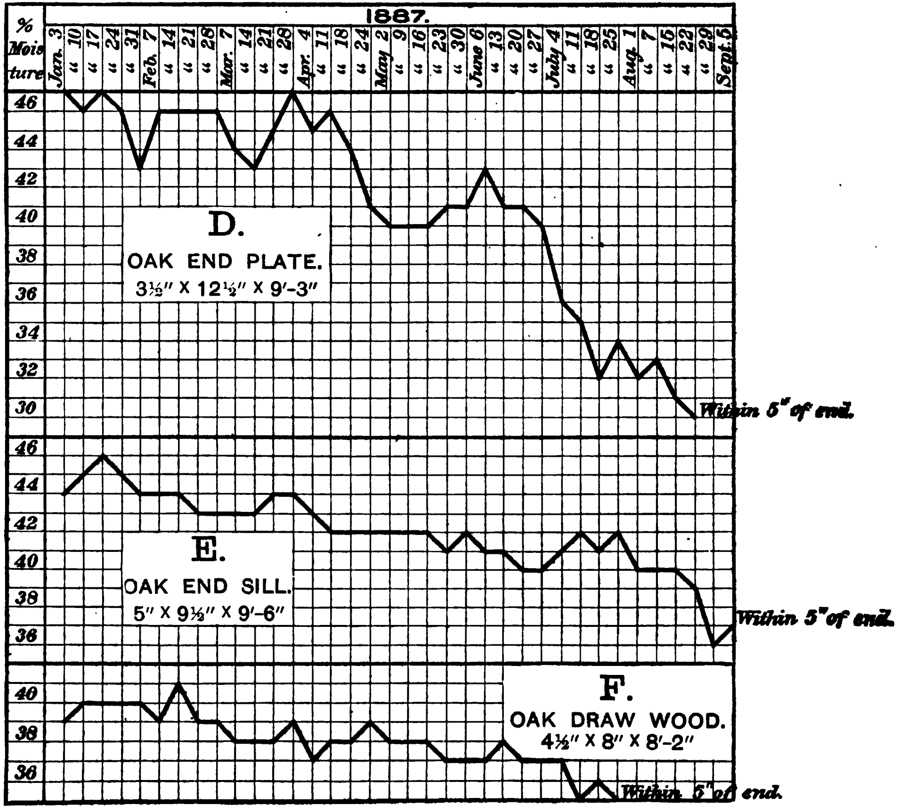
(3) Pine of small dimensions (such as 1 inch flooring "M") will absorb moisture during the wet months. Other woods of small dimensions were not experimented with.

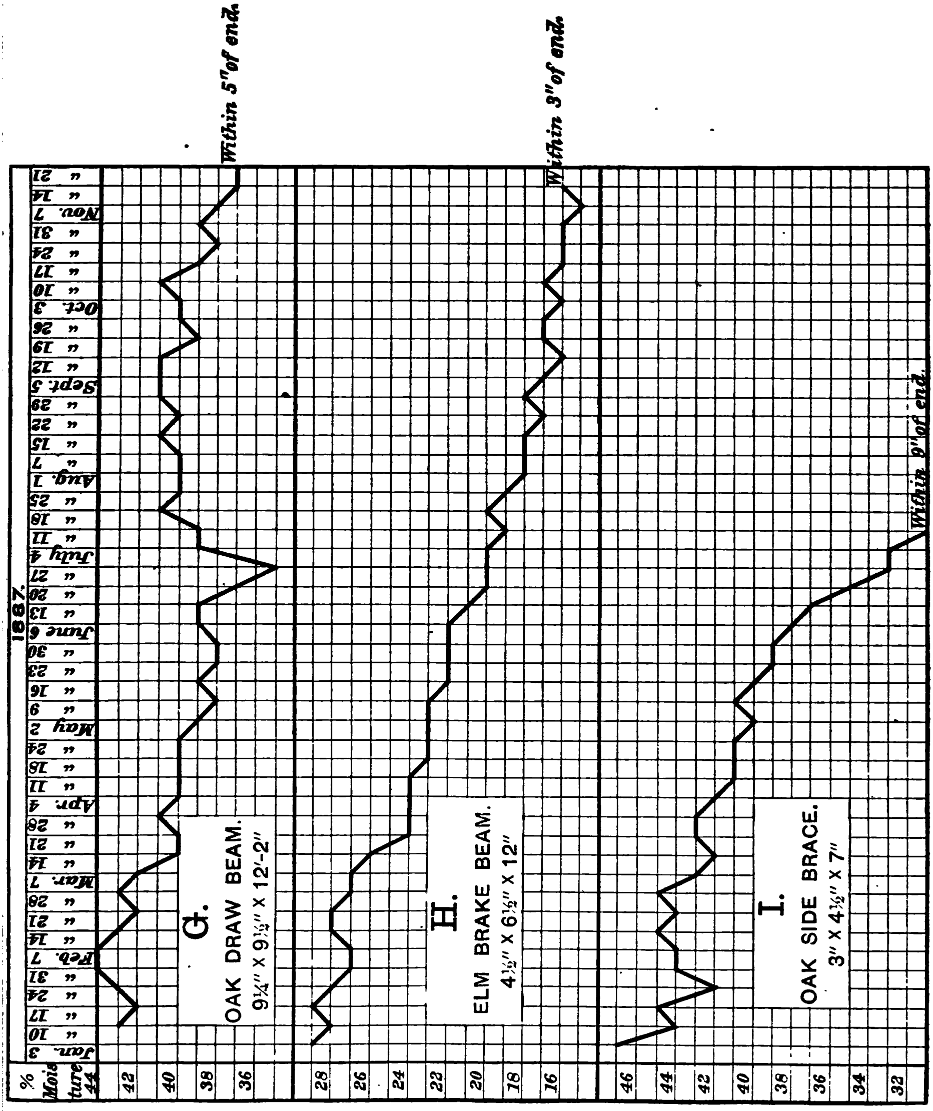
(4) As shown by these experiments one season of average weather is generally sufficient to season woods for purposes of construction.

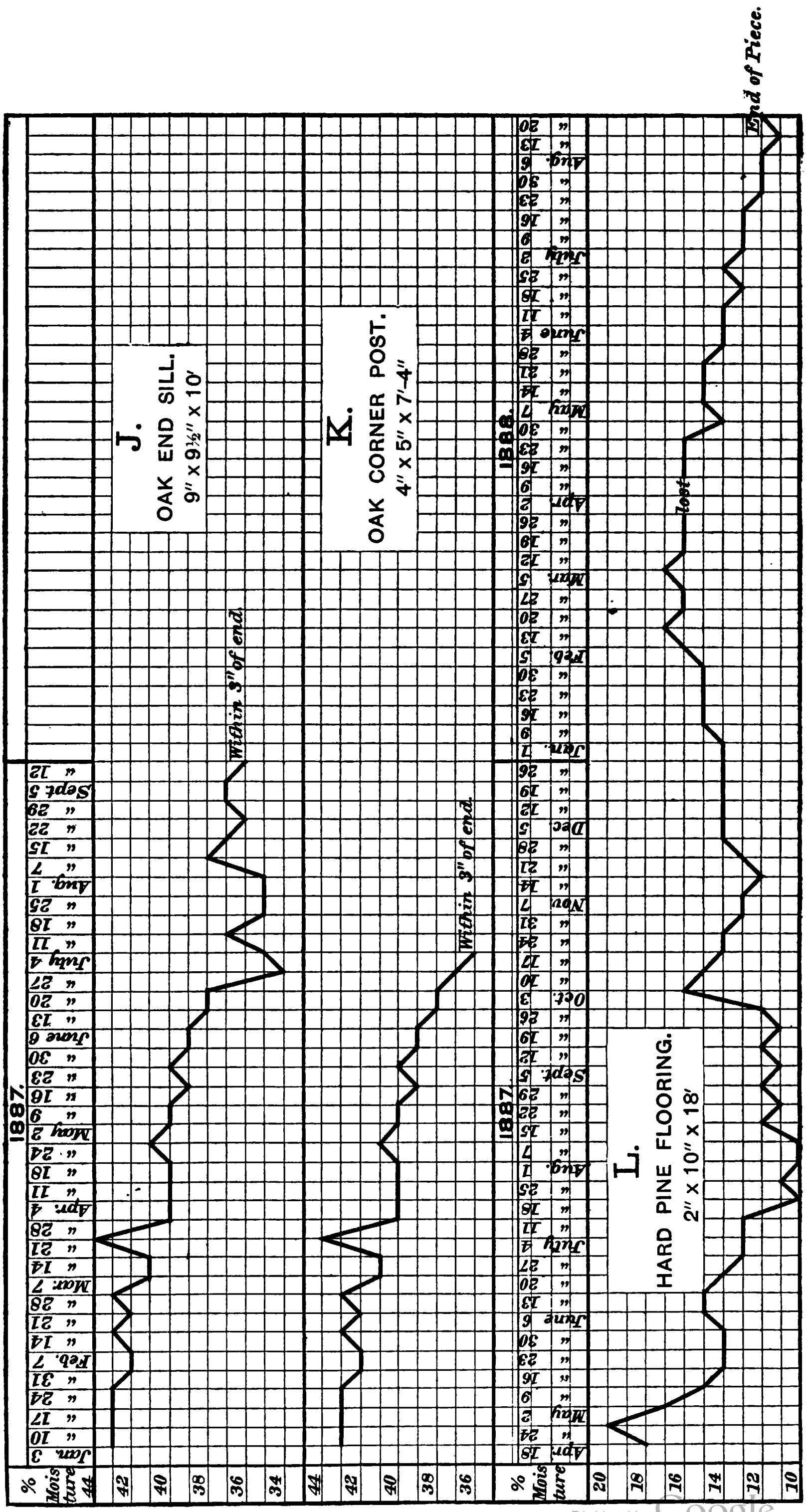
Yours truly,

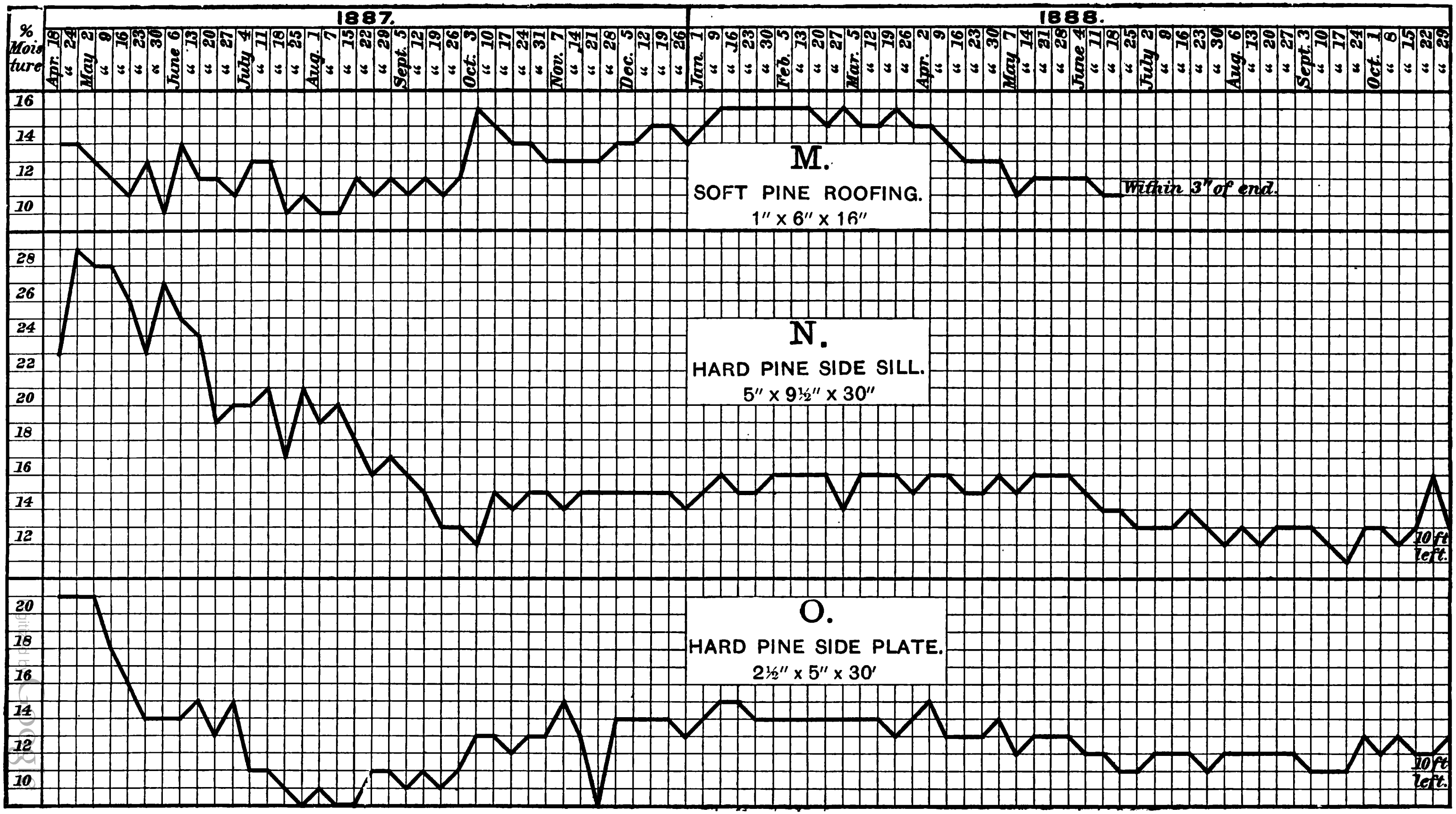
G. H. Ellis,
Chemist.


% Moisture
1887.
1888.
Jan. 3
" 10
" 17
" 24
" 31
Feb. 7
" 14
" 21
" 28
Mar. 7
" 14
" 21
" 28
Apr. 4
" 11
" 18
" 24
May 2
" 9
" 16
" 23
" 30
June 6
" 13
" 20
" 27
July 4
" 11
" 18
" 25
Aug. 1
" 7
" 15
" 22
" 29
Sept. 5
" 12
" 19
" 26
Oct. 3
" 10
" 17
" 24
" 31
Nov. 7
" 14
" 21
" 28
Dec. 5
" 12
" 17
" 26
Jan. 1
" 9
" 16
" 23
" 30
Feb. 5
" 13
" 20
" 27
Mar. 5
" 12
44
42
40
38
36
34
32
30
22
20
18
16
14
12
16
14
12
10
A.
OAK DRAW WOOD.
4¾" X 14" X 17"
Within 3" of end.
B.
ASH CORNER POST.
4" X 9" X 16.
End of Piece.
C.
WHITE WOOD OUTSIDE.
3" X 12" X 16"
Within 3" of end.


1887.
% Moisture
Jan. 3
" 10
" 17
" 24
" 31
Feb. 7
" 14
" 21
" 28
Mar. 7
" 14
" 21
" 28
Apr. 4
" 11
" 18
" 24
May 2
" 9
" 16
" 23
" 30
June 6
" 13
" 20
" 27
July 4
" 11
" 18
" 25
Aug. 1
" 7
" 15
" 22
" 29
Sept. 5
46
44
42
40
38
36
34
32
30
D.
OAK END PLATE.
3½" X 12½" X 9'-3"
Within 5" of end.
46
44
42
40
38
36
E.
OAK END SILL.
5" X 9½" X 9'-6"
Within 5" of end.
40
38
36
F.
OAK DRAW WOOD.
4½" X 8" X 8'-2"
Within 5" of end.


1887.
% Moisture
Jan. 3
" 10
" 17
" 24
" 31
Feb. 7
" 14
" 21
" 28
Mar. 7
" 14
" 21
" 28
Apr. 4
" 11
" 18
" 25
May 2
" 9
" 16
" 23
" 30
June 6
" 13
" 20
" 27
July 4
" 11
" 18
" 25
Aug. 1
" 7
" 15
" 22
" 29
Sept. 5
" 12
" 19
" 26
Oct. 3
" 10
" 17
" 24
" 31
Nov. 7
" 14
" 21
44
42
40
38
36
28
26
24
22
20
18
16
46
44
42
40
38
36
34
32
G.
OAK DRAW BEAM.
9¼" X 9½" X 12'-2"
Within 5" of end.
H.
ELM BRAKE BEAM.
4½" X 6½" X 12"
Within 3" of end.
I.
OAK SIDE BRACE.
3" X 4½" X 7"
Within 9" of end.


1887.
% Moisture
Jan. 3
" 10
" 17
" 24
" 31
Feb. 7
" 14
" 21
" 28
Mar. 7
" 14
" 21
" 28
Apr. 4
" 11
" 18
" 24
May 2
" 9
" 16
" 23
" 30
June 6
" 13
" 20
" 27
July 4
" 11
" 18
" 25
Aug. 1
" 7
" 15
" 22
" 29
Sept. 5
" 12
44
42
40
38
36
34
J.
OAK END SILL.
9" x 9½" x 10'
Within 3" of end.
44
42
40
38
36
K.
OAK CORNER POST.
4" x 5" x 7'-4"
Within 3" of end.
1887.
1888.
% Mois ture
Apr. 18
" 24
May 2
" 9
" 16
" 23
" 30
June 6
" 13
" 20
" 27
July 4
" 11
" 18
" 25
Aug. 1
" 7
" 15
" 22
" 29
Sept. 5
" 12
" 19
" 26
Oct. 3
" 10
" 17
" 24
" 31
Nov. 7
" 14
" 21
" 28
Dec. 5
" 12
" 19
" 26
Jan. 1
" 9
" 16
" 23
" 30
Feb. 5
" 13
" 20
" 27
Mar. 5
" 12
" 19
" 26
Apr. 2
" 9
" 16
" 23
" 30
May 7
" 14
" 21
" 28
June 4
" 11
" 18
" 25
July 3
" 9
" 16
" 23
" 30
Aug. 6
" 13
" 20
20
18
16
14
12
10
L.
HARD PINE FLOORING.
2" x 10" x 18'
Lost
End of Piece.


1887.
1888.
% Moisture
Apr. 18
" 24
May 2
" 9
" 16
" 23
" 30
June 6
" 13
" 20
" 27
July 4
" 11
" 18
" 25
Aug. 1
" 7
" 15
" 22
" 29
Sept. 5
" 12
" 19
" 26
Oct. 3
" 10
" 17
" 24
" 31
Nov. 7
" 14
" 21
" 28
Dec. 5
" 12
" 19
" 26
Jan. 1
" 9
" 16
" 23
" 30
Feb. 5
" 13
" 20
" 27
Mar. 5
" 12
" 19
" 26
Apr. 2
" 9
" 16
" 23
" 30
May 7
" 14
" 21
" 28
June 4
" 11
" 18
" 25
July 2
" 9
" 16
" 23
" 30
Aug. 6
" 13
" 20
" 27
Sept. 3
" 10
" 17
" 24
Oct. 1
" 8
" 15
" 22
" 29
16
14
12
10
M.
SOFT PINE ROOFING.
1″ x 6″ x 16″
Within 3″ of end.
28
26
24
22
20
18
16
14
12
N.
HARD PINE SIDE SILL.
5″ x 9½″ x 30″
10 ft left.
20
18
16
14
12
10
O.
HARD PINE SIDE PLATE.
2½″ x 5″ x 30′
10 ft left.

THE RELATION OF RAILWAYS TO THE TIMBER RESOURCES OF THE UNITED STATES.

BY E. E. RUSSELL TRATMAN, C. E.

(Read before the American Forestry Congress, at Atlanta, Ga., December 8, 1888.)

The report of the Commissioner of Agriculture for 1887, recently published, contains an interesting but brief report from the Chief of the Forestry Division, and this report refers to the Government interest in the development and maintenance of the forests; a matter which is of far greater importance than is generally understood, and which is especially important on account of the rapid destruction of forests through the legitimate demand for timber, through reckless use, and through wasteful practices of burning, herding, etc., while very little practical attention is paid to the question of forest planting or reforesting, although the forest under proper management is capable of furnishing continuous crops. The question considered is, "What is the first duty of the General Government in regard to the forestry question?" It is stated that the natural forests are being rapidly reduced by an increased demand for timber and by reckless use and wanton destruction, and that the annual consumption of wood and wood products is at least double the amount reproduced on our present forest area. The national interest in this question is shown from four points of view: (1) Because the forests properly managed would be the source of a constant supply of timber; (2) because a sound land policy demands attention to forest management to prevent the deterioration of forests and forest lands; (3) because a rational forest policy demands attention to the disturbance of the distribution of water flow by forest devastation and by the denudation of mountains and hills; and (4) because forest planting is a means of ameliorating climatic conditions and making certain regions more habitable.

Other nations have recognized the importance of the forestry problem and have the matter under State administration; for private interest is not sufficient to protect the forest property, since to the individual it is the existing timber alone that is valuable, and he has no care for any but pecuniary considerations. Consequently the State must undertake the management and protection of the forests.

The General Government of the United States owns about 50,000,000 to 70,000,000 acres of forest area, principally in the far West and on the Pacific ranges, and mostly on land not fit for agricultural purposes. The water supplies for the valleys and the agricultural areas of these regions are regulated and influenced to a great extent by the forests, and it is therefore obvious that the matter of preservation and protection of the forests is one of importance to the national prosperity; whereas, in fact, the timber is recklessly used and wasted, while the attempts to prevent the waste are practically ineffectual. A bill to protect the Government forests has, however, been submitted to Congress. The report referred to shows very forcibly the need of legislation in this direction, and of proper management to regulate the cutting, to attend to the maintenance and protection, and to undertake the planting of new forests to furnish a future supply of timber.

Of course these remarks apply to the consumption in total, but the railways are responsible to a considerable extent, both on account of the immense amount legitimately consumed for ties, bridges, trestles, buildings, etc., and on account of their waste and the amount improperly acquired. The report states as follows:

> Every land-grant railway, in addition to its share of the land grant of 75,000,000 acres and the right of way, is permitted to cut timber "for first construction, adjacent to the line of its road." But the railways do not consider "construction" and "adjacent" exactly in the sense in which the lawgivers did, and they have cut wherever, whenever, and for what purpose they chose.

Railway men as a rule do not give much attention to the sources of supply for ties, but, with others, believe blindly in "inexhaustible" forests, or if they do look forward at all to a diminished supply, they usually consider it as too far in the future to require any special attention now. In point of fact, however, this is even now a very important matter, which becomes more serious every year. Forests, although they can be made to furnish regular annual crops, can not be grown in a year, and while present resources are being recklessly drawn upon, few steps are being taken to provide future resources.

There are four ways in which the railways may help to economize the present supply: (1) By taking more care in the selection, cutting, and storing of timber; (2) by the more general use of iron, steel, stone, brick, concrete, etc., for bridges, trestles, buildings, and other construction works; (3) by the introduction of some efficient and economical preservative process; and (4) by the introduction of metal cross-ties. These four methods of economizing will be considered separately.

1. *By taking more care in the selection, cutting, and storing of timber.*—Sufficient investigation has not been made of the availability of different kinds of timber for railway work. For instance, there are probably other kinds of timber besides those now used which are suitable for ties, and, in fact, a circular was issued some months ago by the Forestry Division* showing the advantages of the hitherto unused chestnut

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*See Circular on p. 52.

oak, a species of timber of which the bark was used, but the wood itself left to rot, its value for railway ties not being known or appreciated. As a result of this circular, large numbers of ties have now been made from this wood. Certain specifications for ties which have been published name only the following varieties:

> Oaks of the various kinds, known as "white," "black," "yellow," "rock," "burr," and "post" (no red oak will be received), second-growth white chestnut, red beech, red elm, cherry, maple, butternut, tamarack, and yellow pine of the long-leaved, southern hard pine variety, cut from untapped trees and grown not north of South Carolina. Hemlock may be accepted, but only under special contracts.

But it has been suggested that red oak, black locust, and white and red cedar might be added, and probably others, besides the chestnut oak already referred to. This part of the question is important also in connection with the third part, as the use of preservatives may enable other kinds of timber to be used. It is sometimes specified that there is to be no sap-wood on the face of the ties, which excludes all ties cut from such trees as give only one tie, often the best. With regard to cutting, although over this the railway has often no control, except in the case of new roads through timber country, there is undoubtedly much timber wasted in high stumps and by careless felling, etc., which with a little care might have been available for ties or lumber. In storing, the ties are often stacked up in close piles, without any air-spaces between adjacent ties, and left till wanted, by which time many will probably be found, especially at the bottom of the pile, to be rotten and useless. If they were thrown into a pond or brook, of course under proper supervision, their life when put in the track would be longer than if they had been stacked. Bridge timbers and other lumber should also be properly cared for in storage.

2. *The more general use of iron, steel, stone, brick, concrete, etc., for bridges, trestles, buildings, and other construction works.*—On this point much need not be said. Iron and steel are becoming more and more generally used for bridges and trestles, and many large and some small stations are now built of masonry. There is, however, room for very much greater economy yet to be practiced in the use of timber for railway structures, and it will be practiced more as companies grasp the idea that a heavy outlay in the first place is often economical. This, of course, applies only where the heavy first cost can be afforded; but it applies extensively to wealthy corporations, which continue to spend money and use timber in building and repairing timber trestles, sheds, wharves, etc., instead of laying out a good round sum on permanent works. In this respect much might be learned from European practice.

3. *The introduction of some efficient and economical preservative process.*—Numerous preservative processes have been experimented with and large quantities of preserved ties, piles, and lumber used; but considering the enormous quantity of timber in use on the railways of this country, the step towards economy in this direction is a very insignifi-

cant one. The trouble is to find a good process and to get it thoroughly carried out. Different species of timber and different pieces of the same timber absorb different quantities of the preservative, thus producing an undesirable want of uniformity. This is specially troublesome in the case of ties, some ties lasting for years and others having to be replaced in a short time, which means considerable expense for maintenance of the track. In England, where the creosoting process is generally adopted for ties, some railway companies have their own plant and creosote their own ties, sometimes also sawing their own ties from logs delivered by contract. Some of these plants were described in my paper on "English Railway Track," read at the annual convention of the American Society of Civil Engineers at Milwaukee, Wis., in June, 1888. Too little practical attention has been given to this question, though it seems as if some slow progress was being made. Creosoting is very generally used in England and is very successful, but the kind of creosote used is more expensive in this country. Some very valuable and useful information on this subject is contained in the report of the committee on the preservation of timber, American Society of Civil Engineers, June, 1885, and in Bulletin No. 1 of the Forestry Division for 1887.

4. *By the introduction of metal cross ties.*—This subject, one of the most important in railway matters, from the point of view of the economy and efficiency of the track for operation and maintenance as well as from that of economy in timber, is not given much practical attention in this country. Comparatively little is known in detail of what has been done and is being done in other parts of the world, though it is usually understood that quite a number of experiments have been made in foreign countries. Experiments certainly have been made and are still being made, but the matter, on the whole, is beyond the experimental stage, and metal ties have been regularly adopted on hundreds of miles of track, with most satisfactory results. The reason why the matter has been so neglected in this country, may probably be found in the undeniable *cheapness* of so many of our railways; the fact being frequently overlooked that cheapness is expensive, and that what is saved in construction is paid out over and over again in maintenance and expenses. By this it is not meant to suggest that every road should at once put down metal ties, because there are many cases in which this would be inexpedient if not impracticable, since many Western roads must of necessity be built at as low a rate of first cost as possible; and as the construction of these roads (I refer here only to legitimate enterprises) is absolutely necessary for the development of certain districts, for the benefit of those districts, and incidentally for the benefit of the country at large, there are cases in which, for the present at least, wooden ties may be used and their use put under the head of "legitimate consumption." But there are other classes of railways: there are the roads which, having been cheaply built in the first place,

have built up the district they serve and are being improved to meet the requirements of increased traffic—on many of these roads metal ties might be laid to advantage; then there are the wealthy trunk lines, which instead of consuming great quantities of wooden ties every year for maintenance and renewals, should gradually introduce metal ties on their tracks; and finally there are the new roads in busy parts of the country, which are built in a first-class manner to accommodate a heavy traffic from the beginning—these lines should be laid with a metal track in the first place.

In these four ways the railway systems of the country might aid greatly in economizing the present supply of timber, but, in addition, they might help to restore the forests by establishing plantations and encouraging forestry. This has been done to a small extent, but the length of time necessary for the growth of a "crop" is a hinderance to any movement of this kind. In Pennsylvania, railways already have to go outside the State for their oak ties, and the mining industries in the once heavily timbered coal regions of the same State have to import the props, etc., for the workings. In Europe, steel is coming into extensive use for mines, both for props and beams, and for ties.

Some idea of the consumption of timber by railways may be gathered from the following particulars, which are abstracted from a Report on the Forest Condition of the Rocky Mountains (Department of Agriculture, Forestry Division, Bulletin No. 2), by Col. E. T. Ensign, forest commissioner of Colorado:

Union Pacific Railway.—During 1886 there were used in Idaho, Montana, Wyoming, and Colorado, 686,827 ties and 8,450,969 square feet of dimension timber.

Denver and Rio Grande Railway.—The following native timber was used in Colorado and New Mexico in 1886: 60,000 broad-gauge ties, 740,000 narrow-gauge ties, 3,000,000 feet, B. M., of dimension lumber. The approximate amount of timber required for annual renewals and repairs was 1,023,376 ties, and 5,625,000 feet, B. M., of sawed timber.

Colorado Midland Railway.—The number of ties for the construction of 250 miles of main track and the sidings, was estimated at 900,000, and the number of feet of timber for bridges and other construction work at between 6,000,000 and 7,000,000.

Atlantic and Pacific Railway.—During 1885 the consumption of native pine was 937,240 feet in New Mexico, and 2,028,959 feet, B. M., in Arizona. In 1886, 47,456 ties of native pine and 298,755 feet of native pine dimension lumber were used in New Mexico.

Another form of timber destruction, and one for which the railways are largely responsible, is that of fires; on many lines through tracts of timber there is abundant evidence of this fact in strips of charred stumps and logs along the track, sometimes spreading off into large patches. The spark arresters on many locomotives, especially on lines of minor importance, are very inefficient, and on some little lines in New England over which I have traveled, the wood-burning engines, although fitted with spark arresters, throw out continuous showers of sparks. Some interesting notes in respect to forest fires may be gathered from the reviews of the forestry interest in each State and Territory—given in the annual report of the Division of Forestry for 1887, by Mr. B. E. Fernow, Chief of the Division, which report, as well as other publications of the Division, I recommend for perusal to all persons interested in this important question of our timber supplies. In most cases there are laws and penalties relating to starting fires, etc., but the laws seem generally to be a dead letter; they are rarely enforced, and consequently little heed is paid to them. In New Jersey, the loss from fires for the last fifteen or twenty years is said to have averaged, on a low estimate, $1,000,000 a year, an amount which would nearly pay the entire taxes of the State. In Maryland, the loss by fires, "largely from locomotives," is estimated at between $30,000 and $40,000 a year. The total losses by fire form in the aggregate an enormous amount of timber, representing a wicked waste of material, and consequently of money. On the other hand, the steps taken towards planting are few and insignificant, being almost invariably on a very small scale.

Street railways, too, consume a great amount of timber, and it is probable that the ties, from their being covered up but not protected from moisture, have a short life compared with that of ordinary railway ties. When we reach that station of progress when we shall begin to follow the European precedent of building city railways of iron and concrete, we shall materially reduce one item of consumption of timber. But proper street construction must come before, or at least with, proper street railway construction.

In conclusion, the close relations of railways to the timber supply of the country have, I think, been clearly outlined in this paper, and I sincerely hope that at no distant time the railways will, in effect, cooperate with the Government in the conservation and protection of the timber resources, while at the same time they greatly improve the efficiency and value of their own works.

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